PB-230 591

WATER RESOURCES ACTIVITIES IN THE UNITED STATES. FUTURE WATER REQUIREMENTS OF PRINCIPAL WATER USING INDUSTRIES

Select Committee on National Water Resources,
U. S. Senate

April 1960

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 230 591

Ingram

86th Congress }
2d Session }

COMMITTEE PRINT NO. 8

WATER RESOURCES ACTIVITIES
IN THE
UNITED STATES

FUTURE WATER REQUIREMENTS OF PRINCIPAL WATER-USING INDUSTRIES

SELECT COMMITTEE ON NATIONAL WATER RESOURCES
UNITED STATES SENATE

PURSUANT TO

S. Res. 48
EIGHTY-SIXTH CONGRESS

ECEIV
LIBRARY
AUG 2 1968
FWPCA, OHIO BASIN REGIO
576 COLUMBIA PKWY, CINTI. O

APRIL 1960

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Printed for the use of the Select Committee on National Water Resources

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1960

49195

1

118

SELECT COMMITTEE ON NATIONAL WATER RESOURCES

(Pursuant to S. Res. 48, 86th Cong.)

ROBERT S. KERR, Oklahoma, *Chairman*
THOMAS H. KUCHEL, California, *Vice Chairman*

DENNIS CHAVEZ, New Mexico
ALLEN J. ELLENDER, Louisiana
WARREN G. MAGNUSON, Washington
CLINTON P. ANDERSON, New Mexico
HENRY M. JACKSON, Washington
CLAIR ENGLE, California
PHILIP A. HART, Michigan
GALE W. McGEE, Wyoming
FRANK E. MOSS, Utah

MILTON R. YOUNG, North Dakota
ANDREW F. SCHOEPPEL, Kansas
FRANCIS CASE, South Dakota
THOS. E. MARTIN, Iowa
HUGH SCOTT, Pennsylvania

JAMES E. MURRAY, Montana, ex officio

PAUL McBRIDE, *Chief Clerk*
THEODORE M. SCHAD, *Staff Director*

This letter has been reproduced to correct errors contained in the report of the Department of Commerce to the Senate Select Committee on National Water Resources which appears in Committee Print No. 8, "Future Water Requirements of Principal Water-Using Industries."

U.S. Department of Commerce,
Business and Defense Services Administration,
Washington, D.C., June 21, 1960.

Mr. Theodore Schad,
Staff Director, Senate Select Committee on National Water Resources,
New Senate Office Building, Washington, D.C.

Dear Mr. Schad: I wish to call to your attention certain desirable corrections for part 1 of Committee Print No. 8, entitled "Future Water Requirements of the Principal Water-Using Industries." As now written, in some items entitled "Water use per employee * * * per year" the units are erroneously defined. To correct these, we suggest that you issue an errata sheet setting forth the following revised wording for those items:

1. *Page 2, table 1, section C*

"Water use per employee:" The first item should be "Million gallons per year" (instead of "Billion gallons per year").

2. *Page 6, fifth paragraph, fifth line*

This should read: "6,400,000 gallons per employee in 1954 to 8,100,000 in 1980 and tapering off to 8,000,000 in 2000" (instead of 6,400, 8,100 and 8,000).

3. *Page 57, last paragraph, third line*

This should read: "For the years 1959, 1980, and 2000 these figures are 6,700,000, 8,100,000 and 8,000,000 gallons per employee" (instead of 6,700, 8,100, and 8,000 gallons).

4. *Pages 59 through 66, inclusive, all tables*

Item 6 in each table should read: "Water use per employee (line 2/line 5) * * * millions of gallons" (instead of thousands of gallons).

We believe the report will be of greater value if these corrections are called to the attention of the readers.

Sincerely yours,

Walter L. Picton,
Director, Water and Sewerage Industry and Utilities Division.

STATEMENT BY THE CHAIRMAN

April 18, 1960.

To the Members of the Senate Select Committee on National Water Resources:

Under the provisions of Senate Resolution 48, our committee is directed to study, among other things, the extent and character of water resource activities, both governmental and nongovernmental, that can be expected to be required to provide the quantity and quality of water for use by industry between the present time and 1980. The basic requirement for this study is a project of the future water needs of industry.

The 1954 censuses of manufacturers and of mineral industries showed a total water use of over 12,000 billion gallons annually. Of this, about 85 percent of the fresh water used in the manufacturing industries, exclusive of electric power generation, was in the primary metals, chemicals, woodpulp and paper, petroleum and coal, and food industries. The remainder of industrial water used in the United States is divided among a great many industries using smaller amounts of water. Therefore, in view of the limited time available and the amount of work required for each set of projections, it was decided to concentrate on the major water using industries for the purpose of the committee's studies.

Many projections of future water use are made by various organizations, both governmental and private. In recent years the Federal agencies have shown an increasing awareness of the importance of adequate water supplies in connection with the future growth of the Nation's industries. Therefore I asked the Business and Defense Services Administration of the Department of Commerce, and the Bureau of Mines of the Department of the Interior, to report to the committee on water needs of these major water using industries in the fields of manufacturing and mining. I recognize, of course, that new materials and new processes may be developed which may significantly change the nature of industrial water use in the future, but it is believed that the projections of the past uses are the most reliable available sources of data for the committee's use.

Future water use in the electric power industry is being covered for the committee in another series of studies.

The estimated future demands have been based on indexes of expected growth developed by Resources for the Future, Inc., and made available to the committee for its studies, and also on assumptions of growth developed within the agencies by industry specialists. Depending on the assumptions used, the projected trends of water needs vary somewhat, however, all give an indication of the increasing needs for water in our expanding industry. For example, with the Resources for the Future median projections, the Department of Commerce indicates that 1954 water intake of 7,700 billion gallons for the iron and steel, chemical, pulp and paper, food and beverage, aluminum, and copper industries, will increase to 26,500 billion gallons by 1980, and 61,600 billion gallons by 2000. The Bureau of Mines projects water intake in the mining (including petroleum and natural gas-liquid refining) industries from 1,790 billion gallons in 1954, to 3,765 billion gallons in 1980, and 4,770 billion gallons in 2000. These totals of over 30,000 billion gallons annually in 1980, and over 66,000 billion gallons annually in 2000, when increased in amounts sufficient to take care of the other industries for which lack of time precluded making detailed projections, would indicate a probable range of magnitude on the order of 100 billion gallons a day in 1980, increasing to over 200 billion gallons a day in 2000. This is exclusive of the water requirements of the electric power industry, and of water supplied to industry through municipal water systems.

The reports received in response to my requests are being printed as one of our committee prints dealing with all aspects of water resource activities. Presenting as they do estimates of present use and anticipated future demands for industry, both on a national basis and by water resource regions, it is anticipated that they will be of interest and value not only to the committee, but to other Members of the Senate and to others interested in water problems.

Rob't S. Kerr,
Chairman, Select Committee on National Water Resources.

COMMUNICATIONS

August 7, 1959.

Hon. Frederick H. Mueller,
Secretary of Commerce,
The Department of Commerce,
Washington, D.C.

My Dear Mr. Secretary: As mentioned in my letter of June 15, 1959, concerning the work of the Senate Select Committee on National Water Resources, the committee will be concerned with all aspects of the industrial use of water. The studies relating to water use that have already been completed by the Water and Sewerage Industry and Utilities Division of the Business and Defense Services Administration, under the direction of Mr. Walter Picton, are very helpful, and we look forward to receiving the results of others underway.

In addition to the studies now in process, we would like to have the Business and Defense Services Administration prepare a report for the committee on water needs of major water-using industries. The industries to be included, which it is believed account for over 80 percent of industrial water withdrawals in the United States, exclusive of that withdrawn by the electric power industry, are as follows: food; primary metals, notably iron and steel, aluminum, and copper; chemicals; petrochemicals; petroleum refining and coal products; pulp and paper; and lumber and wood products. These major categories may be subdivided in whatever manner will facilitate the analysis.

In connection with each of the foregoing industries, we would like to have the following:

1. The present location of major water-using plants, levels of output and employment, quantities of water intake and discharge, and purpose of use, for 1954 and any other recent year for which data are available.

2. The trends in water use per unit of product and per employee expected between now and 1980 and 2000; changes in technology and product mix inducing changes in use of water for cooling, process, and waste disposal, including the possibilities of using saline water and air cooling.

3. On the basis of indexes of national production for each industry which will be supplied by Resources for the Future, Inc., a regional distribution of the output of each industry estimated for 1980 and 2000, and estimates of water intake and discharge associated with such outputs.

4. Identification of expected industrial growth, if any, in or near any of the following metropolitan areas, one or more of which is located within each of the industrial water use regions, by 1980 and 2000, with estimates of production, employment, water intake, and water discharge: Boston and Hartford; New York, Philadelphia, and Albany-Schenectady-Troy; Detroit; Washington and Richmond; Chicago and Lansing; Cincinnati and Indianapolis; Nashville; Chattanooga; Birmingham and Columbia; Cedar Rapids and St. Louis; New Orleans; Kansas City, Denver, and Sioux City; Oklahoma City, Amarillo and Little Rock; Houston, Dallas, Fort Worth, and San Antonio; Albuquerque; Phoenix and Grand Junction; Portland and Spokane; Salt Lake City; Los Angeles and San Francisco.

5. Identification of cities, if any, in which industrial output will decline and reasons for and estimated amount of decline.

6. Available information on the cost of water presently being used by these industries by region and metropolitan area; specifications of quality and flow requirements; water use and water costs per unit of output where few or no limitations on water supply exist and where conservation is required to be practiced through recycling or other means; estimated effect on water use of changes in the cost of water; problems, if any, of water supply likely to be encountered by these industries as production rises to the

indicated levels; the degree to which the availability of water will determine the location of new plants between now and 1980 and 2000; and description of technological means of water conservation, discussing the economics of each technique.

Resources for the Future, Inc., is working cooperatively with the committee in putting the information on water supply and demand for all purposes together, by water use regions which approximate the U.S. census industrial water use regions. To help in this work we are asking that information be made available to them informally during the course of the study. Since a number of Federal agencies in addition to Resources for the Future, Inc., are participating in the study, we are requesting that all participants use population, gross national product, and industrial production projections supplied by Resources for the Future. The estimates requested above should be based on middle figures for estimated population and production, however, the possible effects of the high and low limits should also be considered if they appear to be of critical importance with respect to water use in any region.

In addition to the information to be made available to the staff of Resources for the Future as the work progresses, which is needed at the earliest possible time, we would like your report to be completed for the committee in the form of a summary report of not more than about 10,000 words, with whatever tables, charts, appendixes, and graphic illustrations as may be considered necessary, by November 1, 1959.

The committee staff will be glad to discuss any problems which may arise in the preparation of the report with members of the staff of the Business and Defense Services Administration.

Sincerely yours,

ROB'T S. KERR, *Chairman.*

THE SECRETARY OF COMMERCE,
Washington, D.C., December 1, 1959.

Hon. ROBERT S. KERR,
Chairman, Select Committee on National Water Resources,
U.S. Senate, Washington, D.C.

DEAR SENATOR KERR: The report on the water requirements of specified principal water-using industries, requested of the Department of Commerce in your letter of August 7, has now been completed and is submitted herewith.

The basic data from the 1954 census of manufactures, the estimates for 1959 and the projections to 1980 and 2000 for the six industries have been summarized, and comments made upon the national and regional trends, and the regional pattern of distribution of production with its resulting water requirements. I believe you will find that the material has been prepared in accordance with your request and the suggestions of your staff director, Mr. Theodore Schad, with the exception of a few instances in which data were not obtainable on which to base estimates.

Walter L. Picton, Director of the Water and Sewerage Industry and Utilities Division of Business and Defense Services Administration, under whose direction the report was prepared, will of course be available to answer any questions which may arise.

If this Department can be of further assistance, please let us know.

Sincerely yours,

F. H. MUELLER,
Secretary of Commerce.

CONTENTS

PART 1

FUTURE WATER REQUIREMENTS FOR THE PRINCIPAL WATER USING MANUFACTURING INDUSTRIES

Page
Statement by the chairman III
Communications V
Preface XII
Summary report:
  Introduction 1
  Future requirements, based on data compiled by Resources for the Future, Inc 2
    Water intake 2
      Table 1. Water intake and employment 2
    Specific industry data: Production, power, and employment 3
      Steel 4
      Chemicals 5
      Pulp and paper 5
      Food and beverage 6
      Aluminum 6
      Copper 7
  Future requirements, based on data compiled by Business and Defense Services Administration 7
      Table 2. Water intake and employment 8
  Regional distribution of water intake 9
    General 9
    Steel 10
      Table 3. Regional pattern of water intake based on Resources for the Future, Inc., median projections 9
      Table 4. Regional pattern of water intake based on Business and Defense Services Administration median projections 10
    Chemicals 10
    Pulp and paper 11
    Food and beverage 11
    Aluminum 11
    Copper 11
  Regional distribution of employees:
    General 12
      Table 5. Regional pattern of employment based on Resources for the Future, Inc., median projections 12
      Table 6. Regional pattern of employment based on Business and Defense Services Administration median projections 13
    Steel 13
    Chemicals 13
    Pulp and paper 13
    Food and beverage 14
    Aluminum 14
    Copper 14
Metropolitan areas 14
Comments 15

APPENDIX A—SUMMARY CHARTS

Page
Chart 1. Basic assumptions as developed by Resources for the Future, Inc. 19
Chart 2. Basic assumptions as developed by Business and Defense Services Administration 19
Chart 3. Federal Reserve Board indexes of industrial production as developed by Resources for the Future, Inc. 20
Chart 4. Federal Reserve Board indexes of industrial production as developed by Business and Defense Services Administration 20
Chart 5. Increase in water requirements based on Resources for the Future, Inc. basic assumptions 21
Chart 6. Increase in water requirements based on Business and Defense Services Administration basic assumptions 21
Chart 7. Regional increase in water requirements based on Resources for the Future, Inc. basic assumptions 22
Chart 8. Regional increase in water requirements based on Business and Defense Services Administration basic assumptions 23

APPENDIX B. SUMMARY TABLES—REGIONAL WATER INTAKE AND EMPLOYMENT BASED ON RESOURCES FOR THE FUTURE, INC., MEDIAN PROJECTIONS

Table 7. New England region 24
Table 8. Delaware and Hudson region 24
Table 9. Eastern Great Lakes and St. Lawrence region 24
Table 10. Chesapeake Bay region 24
Table 11. Western Great Lakes region 25
Table 12. Ohio region 25
Table 13. Cumberland region 25
Table 14. Tennessee region 25
Table 15. Southeast region 26
Table 16. Upper Mississippi region 26
Table 17. Lower Mississippi region 26
Table 18. Upper Missouri region 26
Table 19. Lower Missouri region 27
Table 20. Eastern Arkansas-White-Red region 27
Table 21. Western Arkansas-White-Red region 27
Table 22. Western Gulf region 27
Table 23. Rio Grande region 28
Table 24. Colorado region 28
Table 25. Pacific northwest region 28
Table 26. Great Basin region 28
Table 27. Central Pacific region 29
Table 28. South Pacific region 29

REGIONAL WATER INTAKE AND EMPLOYMENT BASED ON BUSINESS AND DEFENSE SERVICES ADMINISTRATION MEDIAN PROJECTIONS

Table 29. New England region 29
Table 30. Delaware and Hudson region 29
Table 31. Eastern Great Lakes and St. Lawrence region 30
Table 32. Chesapeake Bay region 30
Table 33. Western Great Lakes region 30
Table 34. Ohio region 30
Table 35. Cumberland region 31
Table 36. Tennessee region 31
Table 37. Southeast region 31
Table 38. Upper Mississippi region 31
Table 39. Lower Mississippi region 32
Table 40. Upper Missouri region 32
Table 41. Lower Missouri region 32
Table 42. Eastern Arkansas-White-Red region 32
Table 43. Western Arkansas-White-Red region 33
Table 44. Western Gulf region 33
Table 45. Rio Grande region 33
Table 46. Colorado region 33
Table 47. Pacific Northwest region 34
Table 48. Great Basin region 34
Table 49. Central Pacific region 34
Table 50. South Pacific region 34

APPENDIX C. FUTURE WATER REQUIREMENTS FOR THE IRON AND STEEL INDUSTRY

Page
Introduction 35
Location of plants 35
Electric power generation at plants 35
Employment and water use per employee 35
Future requirements based on Resources for the Future, Inc., estimates 36
    Production 36
    Water intake and usage 36
Future requirements based on Business and Defense Services Administration estimates 36
    Explanation of Business and Defense Administration estimates 36
    Production 36
    Water intake usage 36
Comments on Resources for the Future, Inc., and Business and Defense Services Administration estimates 36
Metropolitan areas 37
Conclusion 37
Tables based on Resources for the Future, Inc., projections:
    National summary of water use 37
    Regional estimates of water use 37
    Regional distribution of estimated water intake 40
    Regional distribution of estimated number of employees 40
Tables based on Business and Defense Services Administration projections:
    National summary of water use 41
    Regional estimates of water use 41
    Regional distribution of estimated water intake 44
    Regional distribution of estimated number of employees 44

APPENDIX D. FUTURE WATER REQUIREMENTS FOR THE CHEMICALS AND ALLIED PRODUCTS INDUSTRY

Introduction 44
Location of plants or mills 45
Future water requirements 45
    (a) Based on estimates of Resources for the Future, Inc 45
        National 45
        Regional 45
        Metropolitan 46
    (b) Based on Business and Defense Services Administration estimates 46
        National 46
        Regional 46
        Metropolitan 47
Tables based on Resources for the Future, Inc. projections:
    National summary of water use 47
    Regional estimate of water use 47
    Regional distribution of estimated water intake 51
    Regional distribution of estimated number of employees 51
Tables based on Business and Defense Services Administration projections:
    National summary of water use 51
    Regional estimate of water use 52
    Regional distribution of estimated water intake 55
    Regional distribution of estimated number of employees 56

APPENDIX E. FUTURE WATER REQUIREMENTS FOR THE PULP AND PAPER INDUSTRY

Introduction 56
Location of mills 56
Production 57
Future requirements based on estimates of Resources for the Future, Inc 57
    Production 57
    Water intake and usage 57
    Employment 57

Page
Future requirements based on Business and Defense Services Administration estimates 58
  Regions 58
  Metropolitan areas:
    Table: Projection of production for selected metropolitan areas 58
  Comments on estimates based on Resources for the Future, Inc.-Business and Defense Services Administration data 58
Tables based on Resources for the Future, Inc.:
  National summary of water use 59
  Regional estimates of water use 59
  Regional distribution of estimated water intake 62
  Regional distribution of estimated number of employees 63
Tables based on Business and Defense Services Administration:
  National summary of water use 63
  Regional estimates of water use 63
  Regional distribution of estimated water intake 67
  Regional distribution of estimated number of employees 67

APPENDIX F. FUTURE WATER REQUIREMENTS FOR THE FOOD AND BEVERAGE INDUSTRY

Introduction 67
Water intake at plants also generating electricity 68
Location of plants 68
Employment and productivity 68
Future requirements based on Resources for the Future, Inc., data 68
  (*a*) Water intake 68
  (*b*) Production 68
  (*c*) Employment and productivity 69
Future requirements based on Business and Defense Services Administration indexes 69
Metropolitan areas 69
Comparison of Resources for the Future, Inc., and Business and Defense Services Administration 69
Tables based on Resources for the Future, Inc.:
  National summary of water use 70
  Regional estimate of water use 70
  Regional distribution of estimated water intake and number of employees 73
Table based on Business and Defense Services Administration:
  National summary of water use 74
  Regional estimate of water use 77
  Regional distribution of estimated water intake 77
  Regional distribution of estimated number of employees 77

APPENDIX G. FUTURE WATER REQUIREMENTS FOR THE ALUMINUM INDUSTRY

Introduction 78
Location of plants 78
Electric power generation at plants 78
Other background data 78
Production 78
Future requirements, water 79
Tables based on Resources for the Future, Inc., projections (Business and Defense Services Administration the same):
  National summary of water use 79
  Regional estimate of water use 79
  Regional distribution of estimated water intake 81
  Regional distribution of estimated number of employees 81

APPENDIX H. FUTURE WATER REQUIREMENTS FOR THE COPPER INDUSTRY

Introduction 82
Water usage 82
Electric power generation 82
Employment 82

Page

Location of mills 82

Metropolitan areas 82

Business and Defense Services Administration estimates 83

Conclusions 83

Tables based on Resources for the Future, Inc., projections:

  National summary of water use 83

  Regional estimate of water use 84

  Regional distribution of estimated water intake and number of employees 85

Tables based on Business and Defense Services Administration projections:

  National summary of water use 85

  Regional estimate of water use 86

  Regional distribution of estimated water intake 87

  Regional distribution of estimated number of employees 87

PART 2

WATER USE IN THE MINERAL INDUSTRY

Communications 89

Preface 91

Summary table 91

Acknowledgments 91

Metals and nonmetals 91

Petroleum and natural gas 92

Anthracite 97

Bituminous coal and lignite 99

Conclusions 101

TABLES

1. Water use by metal and nonmetal mining industries 1954 and 1958, and estimates for 1980 and 2000 by river basins 93
2. Sources of water used by the mining industry by river basins in 1958 93
3. Sources of water used by the metal and nonmetal mining industries by water use regions in 1954 94
4. Summary of the water intake, discharge, gross and net water use by the petroleum and natural gas industries in 1954 96
5. Water used in crude petroleum and natural gas extraction and contract services with water use of 1 million gallons or more by water use regions, 1954 and estimates for 1980 face 96
6. Water used by petroleum refineries with gross intake of 20 million gallons or more by water use regions 1954 and estimates for 1980 face 96
7. Water use by natural gas liquid plants reporting 1 million gallons or more by water use regions 1954 and estimates for 1980 face 96
8. Water intake, discharge, and gross water use in 1954 per unit of production or processing in the petroleum and natural gas industries 97
9. Water use by Pennsylvania anthracite industry 1954 and estimates for 1980 and 2000 98
10. Water use at bituminous coal and lignite mines in 1954 and estimates for 1980 99
11. Water intake at bituminous coal and lignite mines by source in 1954 and estimates for 1980 100
12. Water intake at bituminous coal and lignite mines in 1954 in gallons per ton 100
13. Water use at bituminous coal and lignite mines in 1954 in gallons per ton 101

PREFACE

The Nation's foremost economists, industrial leaders, developers, and engineers have been concerned for many years over the tremendous rate of growth of total water requirements and the rapid rate of decline in foreseeable water supply. It has been predicted time and again that adequate water supply will be one of the Nation's foremost domestic problems within the next two decades.

The Business and Defense Services Administration (BDSA) of the Department of Commerce has been fully cognizant of the importance of the Nation's future water supply particularly with respect to the future needs of the industrial community. This awareness is attested to by the several studies published by the BDSA, particularly "Water Use in the United States, 1900–1975" and "Water Resources Developments, Capital Investment Values, 1900–1975." These studies also serve to highlight the importance of the tremendous task facing the Senate Select Committee on National Water Resources in assessing this country's future water needs for the development of a Government program to insure a future adequate supply of water. Accordingly, the BDSA was pleased at the opportunity to participate in the Senate committee's investigations pursuant to a request to the Secretary by the Honorable Senator Robert S. Kerr, chairman of that committee.

This report has been prepared in response to that request. The BDSA stands ready to serve the committee in any manner within its means to assist in this important undertaking of developing a program to assure an adequate future water supply and will supplement this report as required in the development of additional data which the short time available for preparation precluded from being included here.

This report was prepared under the direction of Walter L. Picton, Director of the Water and Sewerage Industry and Utilities Division of BDSA, who was assisted by George C. Lovell, in the coordination and correlation of the data and material contributed by Mr. Picton and that prepared by the industry specialists of the six industrial areas covered by this report.

Acknowledgment is made of the cooperation of the Bureau of the Census in their prompt response to requests by the BDSA for special data and tabulations necessary in the completion of this study.

FUTURE WATER REQUIREMENTS FOR THE PRINCIPAL WATER USING MANUFACTURING INDUSTRIES

SUMMARY REPORT

INTRODUCTION

This report projects the anticipated future water intake requirements for six of the principal water using industries of the United States and includes projections of corollary data including employment, water intake per employee, water intake per unit production and significant technological or other factors which will affect the trend of water usage for the industries studied. An important segment of this study covers similar data for the 22 water-use regions adopted by the Senate Select Committee as a basis for its studies.

The specified industries subject of this study and their related Standard Industrial Classification Code (SIC) are as follows: [1]

1. Primary aluminum, 3334
2. Chemical and allied products, 28
3. Primary copper, 3331
4. Food and kindred products, 20
5. Pulp, paper and products, 26
6. Primary pig iron and steel
    - a. Blast furnaces and steel mills, 3311
    - b. Steelworks and rolling mills, 3312

The approved plan and the basic data for developing the projections were furnished by Resources for the Future, Inc. (RFF) a nonprofit, tax-exempt corporation financed by grants by the Ford Foundation, with which the Senate Committee has a working agreement to coordinate efforts of the 15 Federal agencies participating in certain phases of the water supply-demand studies.

The basic economic assumptions supplies by the RFF are graphically illustrated in chart No. 1,[2] which includes high, medium, and low projections for the years 1980 and 2000 for each of the four categories: "Federal Reserve Board (FRB) Index of National Industrial Production," "Gross National Product (GNP) (1959 constant dollars)," "Per Capita Gross National Product (1959 constant dollars)," and "National Population."

The RFF projections of the FRB Index of Industrial Production for each of the six industries as compared with the total national industrial production is portrayed in chart No. 3.

It was decided as a matter of uniformity to use the median indexes supplied by the RFF for all six industries in developing future requirements. In addition, the BDSA for purposes of comparison made another set of projections based on indexes developed within the Agency by the various industry specialist groups. The resulting basic economic assumptions for the same four economic categories described above as projected by the BDSA are graphically shown in chart No. 2.

Chart No. 4 parallels the data of chart No. 3 by graphically depicting the BDSA projections of industrial production for the six industries as compared with the BDSA index of total national industrial production.

In addition to the development of estimates of future water intake requirements for each industry, levels of production, water intake per unit of production, number of employees and water intake per employee were projected for the indicated years. Corollary data to accomplish these projections in addition to the above cited RFF data included: (*a*) Revised list of metropolitan areas, (*b*) water resource regional breakdown and map, (*c*) census of manufactures MC–209 "Industrial Water Use," (*d*) projections of population in certain metropolitan areas, (*e*) projections of rural population in equivalent States (in terms of percentage), (*f*) projections of urban and rural population by water resource region, and (*g*) value added by manufacture by major industry group, by water region and total United States (census).

---

[1] The petroleum and coal products industry (SIC Code 29) the fourth largest manufacturing industrial water user will be reported by the Department of the Interior.

[2] All charts are contained in app. A.

The methods by which these data were employed to arrive at the projections of water intake requirements and the corollary data for the six selected industries are contained in the attached appendixes C through H. The appendixes include also the data compiled for each industry group based on the BDSA indexes.

Estimates have been made also of the proportional distribution of the national totals within the 22 regions with consideration to probable future trends which would influence the applicable industry.

The pertinent highlights of the individual industrial data and the integration of the data of the six separate industries to obtain national industrial totals is reflected in the material which follows.

FUTURE REQUIREMENTS (BASED ON RFF DATA)

WATER INTAKE

The total yearly water intake for all manufacturing establishments according to the 1954 Census of Manufactures amounted to 12,000 billion gallons of which 97.4 percent was by plants requiring 20 million gallons or more per year. The seven specified manufacturing industries covered (6 by BDSA and 1 by Department of Interior) account for 77 percent of total manufacturing industrial water intake. The six industries reported by BDSA account for 65.3 percent of the total data for manufacturing establishments with an intake of 20 million gallons or more. For all manufacturing establishments the percentage coverage for the six industries would represent 60.5 percent. Subsequent comparisons in this report will relate to the six industries only and all data, unless indicated to the contrary will pertain to

TABLE 1.—*Future water requirements, 1954–2000 principal water-using manufacturing industries—Water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billion gallons per year]

Industry	Years							
	1954		1959		1980		2000	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Iron and steel	2,812.0	36.6	3,500.0	35.7	7,123.7	26.8	12,826.5	20.8
Chemical	2,380.0	30.9	3,210.0	32.7	10,800.0	40.7	29,700.0	48.2
Pulp and paper	1,607.0	20.9	2,140.0	21.8	6,893.0	26.0	16,173.0	26.3
Food	590.0	7.7	630.0	6.4	1,000.0	3.8	1,500.0	2.4
Aluminum	263.0	3.4	278.3	2.9	605.2	2.3	1,138.8	1.9
Copper	42.0	.5	49.0	.5	114.0	.4	247.0	.4
Total	7,694.0	100.0	9,807.3	100.0	26,535.8	100.0	61,585.3	100.0
Index	100.0		128.0		345.0		800.0	
Billion gallons daily average	21.1		26.9		72.7		168.7	

B. NUMBER OF EMPLOYERS

Industry	1954 Amount	1954 Percent	1959 Amount	1959 Percent	1980 Amount	1980 Percent	2000 Amount	2000 Percent
Iron and steel	518,690	27.0	517,400	24.8	872,300	22.7	1,335,100	18.7
Chemical	459,000	23.9	505,000	24.2	998,000	26.0	2,230,000	31.3
Pulp and paper	252,000	13.1	321,000	15.4	847,000	22.1	2,028,000	28.4
Food	659,834	34.3	700,000	33.6	1,000,000	26.0	1,300,000	18.2
Aluminum	20,968	1.0	24,866	1.2	96,110	2.5	199,030	2.8
Copper	13,108	.7	15,000	.8	26,000	.7	45,000	.6
Total	1,923,600	100.0	2,083,266	100.0	3,839,410	100.0	7,137,130	100.0
Index	100		108		200		370	

C. UNIT WATER CONSUMPTION

Industry	1954 Amount	1954 Percent	1959 Amount	1959 Percent	1980 Amount	1980 Percent	2000 Amount	2000 Percent
Water use per employee:								
Billion gallons per year	4.0		4.7		6.9		8.6	
Gallons per day	10,958.0		12,905.0		18,940.0		23,641.0	

NOTE.—Details may not add to totals due to independent rounding.

establishments with water requirements of 20 million or more gallons per year.

The total water intake requirements for these six industries based on the RFF median indexes by the year 1980 will amount to some 26,500 billion gallons (approximately 72.7 billion gallons average per day). By the year 2000 these requirements will have risen to over 61,600 billion gallons (168.7 billion gallons average per day). These yearly requirements compare to the census data which report 7,694 billion gallons water intake (over 21 billion gallons per day) for the year 1954. It will be noted in table No. 1A that in terms of 1954 as the base index of 100, the total water intake for the six industries will have multiplied eightfold by the year 2000.

The three major water using industries (steel, chemicals, and pulp and paper) which in 1954 had a combined water intake of 88.4 percent of the total for the six industries will account for 93.5 percent of the total for the six groups by 1980 and 95.4 percent by the year 2000.

The percentage share of each industry group for 1954 and the shift in proportional water intake requirements for the years 1980 and 2000 based on RFF projections may be easily compared by inspection of the percentage columns in table No. IA.

The water intake requirements for the chemical industry group which in 1954 ranked second to steel, 30.9 to 36.6 percent rise, spectacularly requiring 50 percent more water than the second largest industry group, steel, by the year 1980, 40.6 percent versus 26.8 percent, and 83 percent more than the second ranking pulp and paper group by the year 2000, 48.2 percent as compared to 26.3 percent.

The pulp and paper group, third ranking in 1954, will require nearly as much water as the steel industry by 1980 and will rank ahead of steel by over one-fourth (26.3 percent as compared to 20.8 percent) by the year 2000. The two primary metal industries, copper and aluminum, combined with the food industries will have dropped from 11.6 percent in 1954 to 4.7 percent by the year 2000.

Table No. 1 A also shows the quantitative water intake requirements for these industries. The chemical industry in the face of a rapidly expanding industry with high water-usage products will multiply its water intake requirements nearly tenfold by the year 2000 over the year 1959, from 3,200 billion gallons to 29,700 billion. The pulp and paper industry group will require nearly eightfold over the same period, from over 2,000 billion gallons to over 16,000 billion gallons. The steel industry requirements during the same period will have multiplied by 3.5.

Changing technology and the relative stability or growth of the industry involved are the primary causes for the radical difference in the rate of growth of water intake requirements for the several industries. A presentation of the results of these differences is graphically shown on chart No. 5.

SPECIFIC INDUSTRY DATA: PRODUCTION, POWER, EMPLOYMENT

A combined total industry estimate projection for 1980 and 2000 has not been included because of the complexity in developing a unit measure common to all industries. Some available industry production data is in pounds while some is in added value of manufacture. Observations covering self-generation of power, productivity, employment, water usage per employee in addition to future production levels for each industry are covered in the succeeding captioned paragraphs.

The projections of water intake for the six specified industries included consideration of the possibility of reduction in water intake requirements through reuse. Such reduction in water intake per unit of production varies widely among the industries, from practically no reduction in the case of chemicals, primary copper, pulp, and paper, to a 10-percent reduction in food and a 20-percent reduction in iron and steel.

It may be desirable to locate new establishments in areas where water is not abundant and would be costly to provide. This will result in a greater reduction in water intake through recirculation and other technical advances than have been assumed in these projections. This is particularly true for the primary metal industries, steel, copper, and aluminum, and to some extent the chemical and pulp and paper industries. As an illustration, along the Rhine River, in the Ruhr Valley and other highly industrialized European areas, it has already become necessary to practice stringent conservation of water intake and extensive treatment of discharge (primary, secondary, and tertiary) to an extent not generally practiced in the United States.

There are possibilities also of additional fresh water conservation in intake requirements through an increased percentage usage of brackish water (or tide water in the case of establishments located in coastal areas). This applies particularly to the primary metal, chemical, and pulp and paper industries. No attempt has been made to estimate the extent of future reduction of fresh water intake by this practice. It is to be noted that in 1954 a large percentage (about 40 percent) of the water intake by the petroleum and coal products industry group was classified as brackish water.

It will be necessary in projecting public utility energy requirements to give consideration to the future heavy demand for power by the primary aluminum industry. The projections for this industry assumed that no new establishments would generate their own electric power. This impact may be gaged by noting that water intake for processing rises from 16 percent of the total water intake in 1954 to 70 percent by the year 2000, while water intake for power declined from 84 to 30 percent.

The projected total number of employees of the six industries will increase from 1,923,600 in 1954 to 3,839,410 in 1980, and 7,137,130 in 2000. Within these totals the chemical proportion increased from 23.9 percent in 1954 to 31.3 percent in 2000; pulp and paper from 13.1 to 28.4 percent; while steel decreased from 27 percent in 1954 to 18.7 percent, and the food industry from 34.3 to 18.2 percent. The primary copper and aluminum industry together accounted for 1.7 percent in 1954 and 3.4 percent in the year 2000. These changes in employment are occasioned partly by the indexes of industrial production and partly by the varying effects of anticipated future automation and changes in the types of industries contained in the industry group.

Table 1 B indicates that the trend of the last decade in increased productivity per man-hour will continue into the future (largely through automation). On the other hand, the reduction in volume of water intake is not anticipated to parallel the reduction in number of employees per unit of production; accordingly the average intake of 10,958 gallons per day per employee in 1954 is projected to rise to 18,940 in 1980, and to 23,641 by the year 2000.

The anticipated rise in productivity will, of course, be accompanied by a reduction in number of employees per unit of production. The water intake requirement per unit of production will decrease also, but at a much slower rate. In terms of water intake per employee the two factors result in a net increase of 116 percent by the year 2000. This is reflected in the indexes in table No. 1 wherein total employment over the period rises to 370 (using 1954 as the base year) while total water intake rises to 800.

Some highlights of the projections of the specific industries include the following:

Steel.—According to the 1954 census of the 273 establishments of the pig iron and primary steel industries, with a water intake of 20 million gallons or more, 99 (36 percent) accounted for 67 percent of the total water intake; 71.5 percent of that intake was used for cooling and air conditioning and about 23.5 percent for direct processing of the product. The entire industry averaged about 70 percent of its water intake for cooling and air conditioning and 22.8 percent for processing, the balance for miscellaneous uses.

The 99 plants cited above represent that segment of the industry which generate their own electricity and reduced their water intake requirements by over 16 percent through recirculation as compared with a 21-percent reduced requirement through recirculation by the entire industry. It would appear from these data that water is more efficiently utilized by those plants not generating their own electric power. This is not necessarily true. The anomaly is partially explained by the fact that the water utilized in the generation of electricity may be reused in the steel processing (i.e., quenching) and such water may not be identified in he processing statistics and that the average actual quantity per establishment of this special group is higher than the total industry average.

Some further reduction in water requirements was effected also by the intake of about 4-percent brackish water. It was assumed that future water requirements would be further reduced in relation to ton of produce by added recirculation practice and increased use of brackish water. The latter assumption is justified on the basis of future production growth in areas where tidewater would be available.

The projection of water intake requirements for the entire industry taking the above factors into account shows an increase of water intake from 2,812 billion gallons in 1954 to 7,124 billion gallons in 1980 and 12,826 billion gallons in 2000. This reflects a decrease in water requirements per ton of steel production from 31,842 gallons per ton in 1954 to 28,724 gallons in 1980 and 25,653 gallons in 2000.

The number of employees for the entire industry was projected on the assumption that the man-hour requirements per unit of production would be gradually reduced following the trend of the past decade. There will be an increase in the number of employees from 518,690 in 1954 to 872,300 in 1980 and 1,335,100 in 2000 while at the same time the water use per employee will increase from 5,421,000 gallons per employee in 1954 to 8,170,000 gallons in 1980 and 9,724,000 gallons in 2000. (See table No. 1 B.)

Chemical.—For the year 1954 according to census data, 198 (18 percent) of the 1,162 establishments generated their own electric power. These establishments cover that group using 20 million gallons or more of water intake per year. The 198 accounted for 65 percent of the water intake of the total for the 1,162 establishments. The 198 utilized 88 percent of water intake for cooling and air conditioning and 7 percent for processing compared to 83 percent and 9 percent respectively for the remainder. As noted for the steel industry the percentage comparison for processing could be misleading since the magnitude of the quantities must be taken into account.

For the entire industry a sizable reduction in water requirements was effected by recirculation while over 20 percent of the total water intake was brackish water. It appears that the fresh water intake requirement was held to 50 percent of actual use due to the practice of reuse and recirculation. The industry group is composed of a variety of industries with respect to manufacturing processes and water requirements. It would be virtually impossible to predict future water requirements and levels of production for many of the industry segments.

There are many products not known today which may enter into production over the next two or three decades, which added to many new products recently introduced may result in enormous growth in production volume. Many of these products, in the classifications of organics, inorganics, and synthetics will certainly be types the production of which requires large quantities of water per dollar value added in production. These potentials would make it virtually impossible to develop a supportable fluctuating base upon which to project future water requirements. Accordingly the water requirements per dollar of value added for production were projected as a constant ratio on the assumption that the increases in water requirements for certain segments of the industry group would be balanced by conservation and reuse of the industry as a whole.

Another factor which was not evaluated in the projection is the potential usage of sea water as a raw material. Large quantities of chlorine and magnesium are extracted from sea water today and it is highly probable that processes will be perfected that will be used to extract numerous other organics and inorganics from sea water in the future and probably within the period of this study.

Projections of future water requirements were made on the basis of 358 gallons per dollar value added in production expressed in 1959 constant dollars. The resulting projection taking the above factor into account shows an increase in water intake from 2,380 billion gallons per year in 1954 to 10,800 billion gallons in 1980 and 29,700 billion gallons in 2000. (See table 1 A and chart No. 5.)

The number of employees were projected on a basis of 69 employees per $1 million of value added in production. The use of these constant factors results in a constant ratio of water intake of 5.18 million gallons per employee for all the years cited in this report. (See table No. 1 B.)

Pulp and paper.—In 1954 census data show that 425 or nearly half of the 867 establishments with water intake of 20 million gallons or more accounted for 72.5 percent of the water intake with 21 percent of their water intake used for cooling and air conditioning and about 68 percent for processing. These 425 establishments were generating electric power for their own use. The entire industry used 20 percent of its intake for cooling and air conditioning and 69 percent for processing.

In this industry the quantity of water utilized in recirculation, percentagewise, was virtually the same for that generating its own electricity compared to the entire industry; 62 percent compared to 61 percent. Ten percent of water intake for the entire industry was brackish water. The primary pulp and papermills account for about 96.5 percent of the water intake by those establishments using over 20 million gallons. Few of the conversion industries use as much as 20 million gallons, most of them having comparatively small water requirements, purchasing their water from public water utilities.

It was assumed that there would be little or no change in the pattern of water requirements with the exception that certain classes of pulp processing would increase in relation to the total thereby effecting an increase of about 10 percent in the water requirements per ton of product by the year 2000.

A reduction in the water intake per dollar value added in production is anticipated between 1980 and 2000. This reduction is partially due to the anticipated growth of a change in the primary components of pulp and paper production with respect to raw materials, more importantly with larger effect is the anticipated increase in production in areas where the availability of water supply is not abundant or is more costly to obtain. The latter will naturally tend to influence establishments toward greater conservation and more reuse. The results of the projections amount to 537 gallons per dollar of value added in production in 1954 rose to 631 gallons in 1980 and 599 gallons in 2000.

The projections show an increase in water intake from 1,607 billion gallons per year in 1954 to 6,893 billion gallons in 1980 and 16,173 billion gallons in 2000. (See table No. 1 A and chart No. 5.)

Employment was projected on the assumption that only a slight reduction would be effected in the man-hour requirements per unit of production. This leads to an increase in water intake requirements from 6,400 gallons per employee in 1954 to 8,100 gallons in 1980 and tapering off to 8,000 gallons in 2000. (See table No. 1 B.)

Food and beverage.—In this industry 2,114 establishments used over 20 million gallons of water in 1954 according to the 1954 census. Of these, 292 establishments accounted for 37 percent of the water intake of which 53.5 percent was used for cooling and air conditioning and 25 percent for processing. Those 292 establishments generated their own electric power. The pattern for the entire industry was not much different; 50 percent for cooling and air conditioning and 25.5 percent for processing.

Sixty-six percent of the establishments in this industry recirculated water to an extent that the water intake requirements were reduced by 52.5 percent. About 10 percent of the water intake for the entire industry was brackish water further reducing fresh water requirements. It was assumed that the pattern of practice of water use within the industry group would not change appreciably, resulting in a projection of water requirements in accordance with the furnished index of industrial production which was based on population growth. It was assumed that increased water requirements in certain industries would be compensated for by increased utilization of reuse or recirculation. These projections which range from 91 gallons per dollar of value added expressed in 1959 constant dollars in 1954 to 83 gallons by the year 2000 lead to an increase in water intake from 590 billion gallons in 1954 to 1,000 billion in 1980 and 1,500 billion in 2000. (See table No. 1 A and chart No. 5.)

Employment was projected on the assumption that the man-hour requirements per unit of production would be gradually reduced by increased use of automation and further that additional water requirements occasioned by automation would be balanced by increased utilization of recirculation. These assumptions lead to an increase in employment from 659,834 in 1954 to 1 million in 1980 and 1,300,000 in 2000. The water use per employee which was 894,000 gallons per year in 1954 will be 1,000 thousand-gallons in 1980 and 1,153 thousand-gallons in 2000. (See table No. 1 B.)

There will be little if any change in the rate of water requirements per unit of production for processing during the period of study. It is anticipated, however, that in the future fewer new establishments will generate their own electric power which tends to reduce the overall requirements for water intake per unit of production. The combination of these two factors will result in a small reduction from 91 gallons per dollar of value added of production in 1954 to 87 gallons in 1980 and 80 gallons in 2000.

Aluminum.—Six of the 16 establishments producing primary aluminum in 1954 accounted for 93.5 percent of the total water intake for the industry. Within this total 95.5 percent was used for cooling and air conditioning compared to 92.5 percent for the entire industry.

The six establishments cited above produce their own electric power. In the projections it was assumed that these self-owned electric generating plants would continue in operation for the term of their useful life which, with minor replacements and modernization, would extend to 2000, with an increase in the production of electric power about 50 percent by the year 2000. The overall increase in aluminum production in the projection was assumed to be largely accomplished by either new or expanded establishments not generating electric power, thereby reducing the proportion of water requirements utilized for electric power.

The projections show an increase in water requirements from 263 billion gallons per year in 1954 to 605 billion gallons in 1980 and 1,139 billion gallons in 2000. (See table 1 A and chart No. 5.) Since the proportion of those establishments generating their own electricity will decrease there will be a resultant decrease in the average water intake requirements of the entire industry from 180,000 gallons per ton of product in 1954 to 50,000 gallons per ton in 1980 and to 35,240 gallons per ton in 2000. Conversely the estimated water intake for the average generation of electric power for the entire industry will decrease from 151,000 gallons per ton to 24,600 gallons per ton in 1980 and to 10,240 gallons in 2000. In a similar manner the entire industry shows a projected reduction in water intake from 12,542 thousand-gallons per year per employee in 1954, to 6,297 thousand-gallons in 1980 and 5,709 thousand-gallons in 2000. (See table No. 1 B.)

The water intake for the production of aluminum is projected to decrease through technological economies from 29,000 gallons per ton in 1954 to 26,000 gallons per ton in 1980 and to 25,000 gallons per ton in 2000.

Copper.—The primary copper industry had 21 establishments with an intake of 20 million gallons of water or more in 1954 according to August data. Of these 21, 9 accounted for 67 percent of the water intake and of that intake 89 percent was used for cooling and air conditioning and about 4 percent for processing. These nine establishments also generated their own electric power. The balance of the industry used about 64 percent of their water intake for cooling and air conditioning and about 35 percent for processing.

The brackish water intake for the same nine establishments was 83 percent as compared with the entire industry utilization of 67 percent brackish water. The industry effected reduction in basic water requirements by 45 percent through recirculation. Although it has not been verified, it is to be assumed that most of this recirculation involved the reuse of fresh water.

In the projections it was assumed that this pattern of practice would continue with little change, largely because of the characteristics of the areas where the projected future increases in production would likely locate. The projections were made on the basis of about 32,000 gallons per short ton with no reduction in overall intake per ton of product.

The resulting projections show an increase in water intake from 42 billion gallons per year in 1954 to 114 billion gallons in 1980 and 247 billion gallons in 2000. (See table No. 1 A and chart No. 5.)

Employment was projected on the assumption of reduction in man-hours per unit of production to be accomplished through increased automation. Although this might result in additional water requirements per unit of production, it was assumed that such reduction would be balanced by increased utilization of recirculation. The projection of employees from 13,108 in 1954 will grow to 26,000 in 1980 and 45,000 by the year 2000. This reflects an increase of water intake per employee from 3,204 in 1954 to 4,380 in 1980 and 5,490 in 2000. (See table No. 1 B.)

This industry is expected to remain relatively static. There will be little change in the technological pattern of water use, the proportional use of brackish water, the proportion of water used for cooling and air conditioning, or the extent of recirculation. As a result the volume of water intake per unit of production remains virtually unchanged; as 32 gallons per ton in 1959, 32.1 in 1980 and 32.2 in 2000.

FUTURE REQUIREMENTS

(Based on BDSA data)

The basic economic assumptions which the BDSA utilized for the projections in arriving at an alternate set of future water intake and corollary requirements have been noted above. A comparison of the charted assumptions (charts Nos. 1 and

2) reveals that the BDSA assumptions are of about the same magnitude as the low RFF assumptions. The BDSA projections of the FRB indexes for the individual industries are shown in chart No. 4. The technological and other factors affecting the specific industries have been cited above and are equally applicable to this section. Their effect on the projections are basically a matter of degree.

The total national water intake requirements for the six industry groups for the years 1980 and 2000 based on the BDSA projections amount to 21,662 billion gallons and 40,205 billion gallons, respectively. These totals compare with the median RFF projections of 26,536 billion gallons and 61,585 billion gallons for the equivalent years. However, the BDSA totals would not be disparate when compared to projections based on the low RFF projections.

The statistics of the water intake requirements of the six industry groups and the national totals are listed in table No. 2A and are graphically portrayed in chart No. 6. Some comparisons are readily evident. Using 1954 as the base index of 100, the national indexes of total water intake requirements for 1959, 1980, and 2000 (BDSA versus median RFF) are as follows:

	1954	1959	1980	2000
BDSA	100	128	282	523
RFF (median)	100	128	345	800

TABLE 2.—*Future water requirements, 1954–2000, principal water-using manufacturing industries—Water intake and employment based upon BDSA median projections*

A. WATER INTAKE

[Billion gallons per year]

Industry	Years							
	1954		1959		1980		2000	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Iron and steel	2,812.0	36.6	3,500.0	35.7	6,837.0	31.6	8,209.8	20.4
Chemical	2,380.0	30.7	3,210.0	32.7	8,040.0	37.1	19,300.0	48.0
Pulp and paper	1,607.0	20.9	2,140.0	21.8	5,252.0	24.2	10,458.0	26.0
Food	590.0	7.7	630.0	6.4	850.0	3.9	1,000.0	2.5
Aluminum	263.0	3.4	278.3	2.9	605.2	2.8	1,138.8	2.8
Copper	42.0	.5	49.0	.5	78.0	.4	98.0	.3
Total	7,694.0	100.0	9,807.3	100.0	21,662.1	100.0	40,204.5	100.0
Index	100.0		128.0		282.0		523.0	
Billion gallons daily average	21.1		26.9		59.3		110.1	

B. NUMBER OF EMPLOYEES

Industry	1954 Amount	1954 Percent	1959 Amount	1959 Percent	1980 Amount	1980 Percent	2000 Amount	2000 Percent
Iron and steel	518,690	27.0	517,400	24.8	836,720	25.2	843,975	16.9
Chemical	459,000	23.8	505,000	24.3	818,000	24.6	1,549,000	31.1
Pulp and paper	252,000	13.1	321,000	15.4	652,000	19.6	1,320,000	26.5
Food	659,834	34.3	700,000	33.6	900,000	27.1	1,050,000	21.1
Aluminum	20,968	1.1	24,866	1.2	96,110	2.9	199,030	4.0
Copper	13,108	.7	15,000	.7	20,000	.6	23,000	.4
Total	1,923,600	100.0	2,083,266	100.0	3,322,830	100.0	4,985,005	100.0
Index	100		108		173		259	

C. UNIT WATER CONSUMPTION

Industry	1954 Amount	1954 Percent	1959 Amount	1959 Percent	1980 Amount	1980 Percent	2000 Amount	2000 Percent
Water use per employee:								
Million gallons per year	4.0		4.7		6.5		8.1	
Gallons per day	10,958.0		12,905.0		17,861.0		22,096.0	

NOTE.—Details may not add to totals due to independent rounding.

In terms of billions of gallons per day comparisons of the same data show an increase in the RFF projections from 21.1 billions of gallons per day in 1954 to 26.9 billions of gallons per day in 1959, 72.7 billions of gallons per day in 1980 and 168.7 billions of gallons per day in 2000 while the BDSA projections convert to 59.3 billions of gallons per day for 1980 and 110.1 billions of gallons per day in 2000 (1954 and 1959 data are identical in each case).

Although the future water intake requirements for the individual industries varied considerably from that projected with the RFF data, the industries did follow a similar pattern as is noted by comparing the percentage distribution of water intake requirements for the two sets of figures:

Percentage distribution—water intake requirements based on RFF and BDSA data

	1980		2000	
	RFF	BDSA	RFF	BDSA
Chemical	40.7	37.1	48.2	48.0
Steel	26.8	31.6	20.8	20.0
Pulp and paper	26.0	24.2	26.3	26.0
Food	3.8	3.9	2.4	2.5
Aluminum	2.3	2.8	1.9	2.8
Copper	.4	.4	.4	.3

There are wide variations in water intake between the RFF and BDSA projections for five of the six industries. The industrial specialists of BDSA were of the opinion, as pointed out in appendix F, that the median RFF projections for the aluminum industry were virtually identical to BDSA estimates and for that reason no differences from the RFF data were charted.

The greatest deviation occurred in the chemical industry projections. For the years 1980 and 2000 the BDSA data yield 8,040 billion gallons and 19,300 billion gallons compared to 10,800 and 29,700 billion gallons RFF data for the same years.

Similarly the BDSA steel industry data reflects 6,837 billion gallons and 8,210 billion gallons for 1980 and 2000 compared to 7,124 billion gallons and 12,827 billion gallons for the projected years.

The Pulp and Paper industry also depicts a wide variation: 5,252 billion gallons versus 6,893 billion gallons for 1980 and 10,458 billion gallons versus 16,173 billion gallons for the year 2000.

The basis for these variations which include industry trends and technology (such as new methods and automation) are explained in the appropriate appendix for each industry.

It should follow from the above observations that employment and production data would have similar differences (with the exception of the aluminum industry), which is the case. The BDSA projections of total employment for the six industries increase from 1,923,600 in 1954 to 3,322,830 in 1980 and 4,985,005 in 2000.

The water use per employee in the BDSA data, however, is virtually unchanged in relation to the RFF data, increasing from 4 million gallons per year in 1954 to 6.5 million gallons in 1980 and 8.1 million gallons (22,096 gallons per day) in 2000. The RFF usage for the same years is 6.9 and 8.6 million gallons (23,641 gallons per day).

REGIONAL DISTRIBUTION OF WATER INTAKE

General.—The BDSA industry specialists, based on their intimate knowledge of the technology and trends within the respective industries, distributed the water intake requirements as summarized above for the years 1980 and 2000 among the 22 national water regions. The explanation of this distribution and the applicable technical factors are included under the appropriate industry report, appendixes C through H.

Census data covering the year 1954 reveal that the total water intake for the six industries was nearly 7,700 billion gallons, of which over 21 percent was withdrawn in the Ohio region, nearly 15 percent in the Western Great Lakes region, nearly 13 percent in the Eastern Great Lakes and St. Lawrence region, over 8 percent each in the Western Gulf region and the Delaware and Hudson region, 7 percent in the Southeast region and nearly 6 percent in the Chesapeake Bay region. These seven regions accounted for 77 percent of the total while the other 15 regions, accounting for 23 percent, range downward from 4 percent to less than 1 percent. (See table No. 3 below and chart No. 7.)

TABLE 3.—*Future water requirements—principal water-using industries—regional pattern of water intake based on RFF median projections*

Region	Water intake in billion gallons per year			
	1954	1959	1980	2000
New England	312.3	403.5	933.1	2,005.9
Delaware and Hudson	618.0	760.6	1,713.3	3,444.2
Eastern Great Lakes and St. Lawrence	974.6	1,271.2	3,054.8	6,354.8
Chesapeake Bay	439.0	589.0	1,669.0	3,604.0
Western Great Lakes	1,116.3	1,313.4	2,915.8	5,743.6
Ohio	1,629.0	2,068.4	4,325.0	8,040.1
Cumberland	18.0	33.0	100.0	232.0
Tennessee	197.8	253.2	736.5	1,798.0
Southeast	534.2	739.3	2,529.3	6,394.8
Upper Mississippi	312.0	358.0	640.0	1,152.0
Lower Mississippi	188.6	210.4	510.4	1,547.5
Missouri, upper	62.3	65.8	121.5	526.7
Missouri, lower	31.0	32.4	75.6	259.4
Arkansas-White-Red, eastern	153.7	171.0	384.6	840.2
Arkansas-White-Red, western	31.0	37.0	96.3	352.5
Western gulf	642.2	882.1	3,550.4	11,565.2
Rio Grande	8.0	9.4	20.5	216.6
Colorado	4.5	6.2	12.1	156.6
Pacific Northwest	287.4	433.9	2,662.2	6,123.1
Great basin	22.1	26.0	59.9	185.9
Central Pacific	80.2	102.2	283.0	743.3
South Pacific	29.6	40.5	108.8	299.0
Total	7,694.0	9,807.3	26,535.8	61,585.3

NOTE. Details may not add to totals due to independent rounding.

For the year 2000 the volume of water intake increases to nearly 61,600 billion gallons (Resources for the Future, Inc., data). Of this total, the Western Gulf region ranks first with nearly 19 percent of water withdrawal followed by 13 percent in the Ohio region, over 10 percent each in the Southeast region, Eastern Great Lakes, and St. Lawrence region, nearly 10 percent in the Pacific Northwest region, over 9 percent in the Western Great Lakes region, and nearly 6 percent each in the Chesapeake Bay region and the Delaware and Hudson region. These eight will account for 83 percent of the total while the other 14 regions will account for 17 percent ranging from 3 percent to less than 1 percent. (See table 3 and chart 7.)

Projections based upon the BDSA assumptions result in a very similar rank for the volume of water withdrawn (see table 5 and chart 8), although the total water intake is only about two-thirds as large as the Resources for the Future, Inc., based projections for the year 2000. The pattern may be distorted due to the fact that for some of the industries no production within certain regions was assumed for establishments using 20 million gallons or more. Obviously, there is a possibility that some production would be initiated in those regions. In this event the net effect would be an increase in water intake for some coastal regions with a corresponding reduction in water intake for some of the noncoastal regions.

TABLE 4.—*Future water requirements principal water-using industries, regional pattern of water intake based on BDSA median projections*

Region	Water intake in billion gallons per year			
	1954	1959	1980	2000
New England	312.3	403.5	716.0	1,305.2
Delaware and Hudson	618.0	760.6	1,431.8	2,230.0
Eastern Great Lakes and St. Lawrence	974.6	1,271.2	2,628.8	4,124.0
Chesapeake Bay	439.0	589.0	1,350.0	2,335.0
Western Great Lakes	1,116.3	1,313.4	2,602.5	3,698.6
Ohio	1,629.0	2,068.4	3,734.0	5,260.1
Cumberland	18.0	33.0	75.0	151.0
Tennessee	197.8	253.2	559.5	1,202.8
Southeast	534.2	739.3	1,971.3	4,163.8
Upper Mississippi	312.0	358.0	532.0	748.0
Lower Mississippi	188.6	210.4	415.4	1,059.5
Missouri, upper	62.3	65.8	97.8	340.1
Missouri, lower	31.0	32.4	62.8	168.7
Arkansas-White-Red, eastern	153.7	171.0	314.9	592.1
Arkansas-White-Red, western	31.0	37.0	79.1	232.2
Western gulf	642.2	882.1	2,702.8	7,590.3
Rio Grande	8.0	9.4	14.0	129.0
Colorado	4.5	6.2	9.6	101.8
Pacific Northwest	287.4	433.9	2,002.8	3,979.9
Great basin	22.1	26.0	50.4	113.3
Central Pacific	80.2	102.2	222.5	484.5
South Pacific	29.6	40.5	88.3	194.2
Total	7,694.0	9,807.3	21,662.1	40,204.5

NOTE.—Details may not add to totals due to independent rounding.

With respect to specific industries, the regional patterns (shown in charts 7 and 8, app. A, and tables 7-50, app. B) are affected as described in the sections which follow:

Steel.—In the base year 1954 about 37 percent of the water intake was withdrawn in the Ohio region, more than 26 percent in the Western Great Lakes region, about 17 percent in the Eastern Great Lakes and St. Lawrence region, nearly 7 percent in the Delaware and Hudson region, and over 5 percent in the Chesapeake Bay region. The remaining 17 regions ranged downward from 3 percent to negligible or no water intake.

By the year 2000, based on RFF data, the Western Great Lakes region will rank first with about 29 percent of the total water withdrawal for the industry, the Ohio region about 25 percent, the Eastern Great Lakes and St. Lawrence over 22 percent, the Delaware and Hudson nearly 9 percent, and the Chesapeake Bay over 6 percent. The remaining 17 regions range downward from 3 percent to negligible withdrawal.

The projections based upon the BDSA assumptions follow the same pattern although the volumes of water withdrawal would be only about two-thirds as large for the year 2000 as that based on RFF data. (See charts No. 7 and 8.)

Chemicals.—In the base year 1954 nearly 21 percent of the water intake in the Ohio region was withdrawn, nearly 20 percent in the Western Gulf region, nearly 15 percent in the Eastern Great Lakes and St. Lawrence region, nearly 10 percent in the Delaware and Hudson region, about 7 percent in the Western Great Lakes region, and about 6 percent each in the Tennessee region and Chesapeake Bay region. The remaining 15 regions accounting for the balance of 15 percent, range downward from 4½ percent to negligible withdrawals.

By 2000 based on RFF data, the water intake pattern will be changed with about 36 percent withdrawn in the western gulf region, nearly 15 percent in the Ohio region, about 10 percent in the Eastern Great Lakes and St. Lawrence region, nearly 7 percent in the Southeast region, nearly 7 percent in the Delaware and Hudson region, nearly 6 percent in the Chesapeake Bay region, and nearly 5 percent each in the Western Great Lakes and in the Tennessee regions. The remainng 9 percent is distributed among the 14 regions, ranging downward from about 3 percent to negligible quantities of withdrawal.

Based on the BDSA assumptions, the water intake will present a similar distribution pattern, although the volumes of water intake are only about 65 percent as large as in the year 2000. (See charts No. 7 and 8.)

Pulp and paper.—For the base year 1954 about 20 percent of the water intake was withdrawn in the Southeast region, nearly 16 percent in the New England region, about 14 percent in the Pacific Northwest, nearly 9 percent in the Western Great Lakes region, about 7 percent each in the Upper Mississippi, the Eastern Great Lakes, and St. Lawrence and the Chesapeake Bay regions. The remaining 15 regions accounting for 20 percent ranged downward from 6 percent to negligible volumes, 3 regions showing none.

The projections to 2000 based on RFF data show quite a difference in pattern. The Pacific Northwest region will take first rank with about 34 percent of the withdrawal, the Southeast about 24 percent, New England over 10 percent, and the Chesapeake Bay over 6 percent; the remaining 18 regions accounting for 26 percent, ranged downward from over 2 percent to practically negligible withdrawals.

The projections based on the BDSA assumptions show a similar pattern, although volume of water withdrawal is estimated to be about two-thirds as large as the RFF figures by the year 2000. (See charts 7 and 8.)

Food and beverage.—In the base year 1954 nearly 15 percent of the water intake was withdrawn in the Upper Mississippi region, over 11 percent each in the Delaware and Hudson region, and in the Western Great Lakes region, about 8 percent each in the Upper Missouri region and the Ohio region, and nearly 7 percent in the Lower Mississippi. The remaining 16 regions accounting for 40 percent range from 5 percent down to less than 1 percent.

The projections to 2000, based on RFF data, show that the Upper Mississippi region will still rank highest with 12 percent of the water withdrawal, the Western Great Lakes almost 12 percent, the Central Pacific nearly 11 percent, the Delaware and Hudson 10 percent, the Ohio region over 7 percent, the Upper Missouri 7 percent, and the Lower Mississippi over 5 percent.

The projections based upon the BDSA assumptions present similar patterns of withdrawal which are only about two-thirds as large in the year 2000. The wide variations in increase of water requirements from the base year 1954 is the result of distributing the increase in requirements on the basis of population growth. (See charts 7 and 8.)

Aluminum.—In the base year 1954 nearly 40 percent of the water intake by the primary aluminum industry was withdrawn in the Western gulf region, nearly 30 percent in the Lower Mississippi region, and over 20 percent in the Eastern Arkansas-White-Red region. The other 19 regions accounting for 10 percent ranged down from 4 percent in the Pacific Northwest down to 0.5 percent in the Southeastern region; 15 of these show no production in 1954.

In projecting production to the year 2000 based on RFF data no production was estimated except for the eight regions producing in 1959. However, shipments of foreign bauxite may result in production in the Central Pacific, Chesapeake Bay, Delaware and Hudson, and the Western Great Lakes regions in future years, although the industrial specialists felt that insufficient information was available on which to base an estimate of production, or the percentage of the total national production which might be located in each region.

In the projection to 2000 for eight regions the water intake assumes a different rank. About 23 percent will be withdrawn in the Western Gulf region, 22 percent in the Pacific Northwest, 16 percent in the Ohio region, 14 percent in the Lower Mississippi, and 11 percent in the Eastern Arkansas-White-Red region, while the other three regions range from about 8 percent for the Tennessee region down to less than 2 percent in the Southeast region. (See chart 7.)

The above observations apply to projections based upon RFF assumptions as well as the BDSA projections because the RFF index of industrial production for the aluminum industry was considered to be in line with BDSA estimates. (See charts 7 and 8.)

Copper.—In the base year 1954 nearly 60 percent of the water intake by the primary copper industry was withdrawn in the Delaware and Hudson region, over 16 percent in the Rio Grande region, and 10 percent in the Great Basin. Four other regions were small or negligible, accounting for only 14 percent of the total; 15 regions showed none or negligible production.

In projecting the production to the year 2000 based on RFF data the industrial specialists assumed that no production would occur in 15 of these regions. However, as in the case of aluminum, shipments of foreign ore may initiate production in the Central Pacific, Western Gulf, Lower Mississippi, Southeast, Chesapeake Bay and/or Eastern Great Lakes, although it would be difficult to estimate what the separate regional percentage of the national total would be.

In the projection to 2000 for the balance of the seven regions, the water intake was projected utilizing virtually the same pattern as for 1954 so that 64 percent will be withdrawn in the Delaware and Hudson region, about 14 percent in the Rio Grande region, and 9 percent in the Great Basin. The other four regions have a comparatively small withdrawal, ranging from about 5 percent in the Pacific Northwest down to less than 1 percent in the Western Great Lakes. (See chart 7.)

The projections based upon the BDSA assumptions present a very similar rank, although the figures for total water intake are only about 40 percent as large as the RFF in the year 2000. (See charts 7 and 8.)

Regional Distribution of Estimated Number of Employees

General.—The BDSA industry specialists, based on their knowledge of the technology and trends within their respective industries, distributed the employment as estimated for the years 1980 and 2000 among the 22 water regions. The explanation of this distribution and the factors involved are included under the appropriate report, Appendixes C through H.

Census data covering the year 1954 reveal that the total employment for the six industries was over 1,900, of which nearly 19 percent were employed in the Ohio region, over 14 percent in the Delaware and Hudson region, nearly 13 percent in the Western Great Lakes region, 9 percent in the Eastern Great Lakes and St. Lawrence region, over 8 percent in the Upper Mississippi region, over 6 percent each in the Chesapeake Bay region and the Southeast region, and nearly 4 percent in the New England region. The remaining 14 regions ranged downward from about 3 to 1½ percent. (See table 5.)

Table 5.—*Future water requirements, principal water-using industries, regional pattern of employment based on RFF median projections*

Region	Number of employees			
	1954	1959	1980	2000
New England	73, 104	83, 750	108, 600	343, 200
Delaware and Hudson	273, 103	288, 390	454, 710	757, 670
Eastern Great Lakes and St. Lawrence	172, 036	190, 000	346, 000	615, 900
Chesapeake Bay	118, 030	124, 000	250, 500	453, 700
Western Great Lakes	243, 016	251, 525	419, 900	699, 645
Ohio	359, 367	380, 050	586, 400	917, 700
Cumberland	9, 500	12, 400	27, 000	57, 960
Tennessee	38, 904	42, 045	80, 600	167, 700
Southeast	116, 122	135, 500	232, 260	711, 190
Upper Mississippi	155, 402	163, 200	242, 000	381, 500
Lower Mississippi	35, 250	38, 800	71, 900	185, 400
Missouri, upper	45, 954	45, 840	66, 700	162, 965
Missouri, lower	15, 064	13, 900	23, 800	60, 340
Arkansas-White-Red, eastern	29, 479	31, 450	68, 650	148, 100
Arkansas-White-Red, western	21, 061	20, 100	30, 500	68, 250
Western gulf	59, 518	67, 550	142, 700	300, 720
Rio Grande	2, 926	3, 270	5, 540	30, 250
Colorado	3, 964	4, 645	8, 400	41, 210
Pacific Northwest	47, 996	60, 350	255, 950	549, 830
Great Basin	15, 185	16, 100	27, 300	60, 300
Central Pacific	52, 050	64, 000	130, 000	251, 300
South Pacific	36, 501	47, 800	91, 800	179, 060
Total	1, 923, 600	2, 083, 366	3, 830, 410	7, 137, 190

For the year 2000 the number of employees increases to over 7 million (RFF data). Of this total the Ohio region ranks first with nearly 13 percent of the employees, nearly 11 percent in the Delaware and Hudson region, nearly 10 percent in the Southeast region, and 10 percent in the Western Great Lakes region, nearly 9 percent in the Eastern Great Lakes and St. Lawrence region, nearly 8 percent in the Pacific Northwest, over 6 percent in the Chesapeake Bay region, over 5 percent in the Upper Mississippi region, nearly 5 percent in the New England region, over 4 percent in the Western Gulf region, and nearly 4 percent in the Central Pacific region. The remaining 11 regions ranged downward from nearly 3 percent to less than 1 percent.

Projections based on the BDSA assumptions result in a very similar rank for the number of employees (see table 6), although the total is only about 70 percent as large. The pattern may be slightly distorted due to the fact that in the case of some of the industries no production was estimated in some regions by establishments using 20 million gallons of water or more in 1980 and 2000, although there is a possibility that production might be initiated in some of these regions during the period covered by the study.

TABLE 6.—*Future water requirements, principal water-using industries, regional pattern of employment based on BDSA median assumptions*

Region	Number of employees			
	1954	1959	1980	2000
New England	73,104	83,750	134,350	231,550
Delaware and Hudson	273,103	288,390	400,890	544,200
Eastern Great Lakes and St. Lawrence	172,036	190,600	305,300	415,300
Chesapeake Bay	118,090	124,000	222,750	312,300
Western Great Lakes	243,016	251,525	372,050	483,575
Ohio	359,387	380,050	531,000	635,200
Cumberland	9,500	12,400	21,800	39,600
Tennessee	38,904	42,046	68,030	122,350
Southeast	116,122	135,500	273,060	477,330
Upper Mississippi	155,402	168,200	209,300	279,760
Lower Mississippi	35,250	36,800	62,300	133,150
Missouri, upper	45,954	45,840	57,900	117,050
Missouri, lower	15,064	13,900	20,500	41,750
Arkansas-White-Red- eastern	29,479	31,450	56,800	104,300
Arkansas-White-Red- western	21,081	20,100	27,950	47,000
Western gulf	59,518	67,550	123,350	219,200
Rio Grande	2,936	3,270	4,200	19,450
Colorado	3,964	4,645	7,020	26,975
Pacific Northwest	47,996	60,350	204,500	379,925
Great Basin	15,185	16,100	23,780	38,400
Central Pacific	52,059	64,000	114,000	187,850
South Pacific	36,501	47,500	82,000	128,800
Total	1,923,600	2,083,266	3,322,830	4,985,005

With respect to specific industries, the regional patterns (see tables 7–50, app. B) are affected as described in the sections which follow.

Steel.—In 1954 about 41 percent of the employees in the pig iron and primary steel industry were located in the Ohio region, over 15 percent in the Western Great Lakes region, 13 percent in the Eastern Great Lakes and St. Lawrence region, 8 percent in the Delaware and Hudson region, and over 7 percent in the Chesapeake Bay region. Five regions had none or negligible production; the remaining 12 regions ranged downward from 4 percent to less than 1 percent. In the projection to the year 2000, the Colorado region which had no production in 1954 was estimated to increase the production of 1959 during the years under study.

By the year 2000, based on RFF data, the Ohio region ranks first with about 28 percent of the employees, the Eastern Great Lakes and St. Lawrence nearly 18 percent, the Western Great Lakes over 17 percent, the Delaware and Hudson regions about 10 percent, and the Chesapeake Bay region over 8 percent; the remaining 16 regions range downward from 6 percent to negligible number of employees.

The projections based upon BDSA assumptions follow approximately the same pattern although the number of employees would be only about two-thirds as large in the year 2000. (See tables 1 and 2.)

Chemicals.—In 1954 over 21 percent of the employees in the chemicals industry group were located in the Delaware and Hudson region, nearly 15 percent in the Ohio region, over 10 percent in the Eastern Great Lakes and St. Lawrence region, over 9 percent in the Western Great Lakes region; nearly 7 percent in the Chesapeake Bay region, nearly 6 percent each in the Western Gulf, Southeast and Upper Mississippi, over 5 percent in the Tennessee region. The remaining 13 regions range downward from 3 percent to negligible number of employees.

In 2000, based on RFF data, with respect to employment the pattern is somewhat similar to 1954. The Delaware and Hudson region contains over 18 percent of the employees, the Ohio region contains nearly 15 percent, the Eastern Great Lakes and St. Lawrence region over 10 percent, the Western Great Lakes region over 9 percent, the Western Gulf region over 7 percent, the Southeast region nearly 7 percent, the Chesapeake Bay region over 6 percent, and the Upper Mississippi nearly 6 percent The remaining 14 regions range downward from about 4 percent to a very small number of employees.

The projections based upon the BDSA assumptions show almost the same pattern although the total number of employees is 70 percent as large in 2000. (See tables 1 and 2.)

Pulp and paper.—In the base year 1954 [illegible] 15 percent of the employees in the pulp, paper, and products industry group were located in the New England region, nearly 14 percent in the Southeast region, nearly 11 percent in the Western Great Lakes region, over 10 percent in the Delaware and Hudson region, nearly 9 percent in the Upper Mississippi region, about 8 percent in the Eastern Great Lakes and St. Lawrence region, over 7 percent in the Ohio region, nearly 7 percent in the Pacific Northwest, and about 6 percent in the Chesapeake Bay region. The remaining 11 regions ranged downward from 4 percent to negligible volumes of withdrawal, 3 showing none.

In the projections to 2000, based on the RFF data, the Pacific Northwest region ranks first with nearly 21 percent of the employment, the Southeast region 20 percent, the New England region 13 percent, the Chesapeake Bay region over

6 percent, the Eastern Arkansas-White-Red region over 4 percent, and the remaining 17 regions ranging downward from under 4 percent to less than 1 percent. (See tables 1 and 2.)

On the other hand, the projections based upon the BDSA assumptions show only about two-thirds as many employees, the reduction largely being in the regions which showed the highest percentages in the RFF projections.

Food.—In the base year 1954 over 15 percent of the employees in the food and beverage industry were located in the Delaware and Hudson region, over 14 percent each in the Upper Mississippi and the Western Great Lakes regions, over 9 percent in the Ohio region, about 5 percent each in the Eastern Great Lakes and St. Lawrence, the Upper Missouri and the Central Pacific regions. The remaining 15 regions range from less than 5 percent down to less than 1 percent. In the projections to 2000 the regional distribution pattern of production reflects the regional population which this industry serves.

In the year 2000, based on RFF data, the Western Great Lakes ranks first with over 14 percent of employees, the Delaware and Hudson over 13 percent, the Upper Mississippi over 12 percent, the Central Pacific 11 percent, the Ohio 9 percent, the Chesapeake Bay region about 6 percent, the Eastern Great Lakes and the South Pacific nearly 6 percent each, the remaining 15 regions ranging from 5 percent down to over 1 percent.

Projections based upon the BDSA assumptions take a similar pattern, but show only about 80 percent as many employees. (See tables 1 and 2.)

Aluminum.—In the base year 1954 over 25 percent of the employees in the primary aluminum industry were located in the Pacific Northwest region, about 19 percent in the Western Gulf region, nearly 17 percent in the Tennessee region, 12 percent in the Eastern Arkansas-White-Red region, about 11 percent in the Eastern Great Lakes and St. Lawrence, and also the Lower Mississippi, and less than 4 percent in the Southeast region. Fourteen regions had no production in 1959, and the projections to 2000 show no employment for those regions.

In the year 2000 the relative rank of the regions with respect to employment changes somewhat. The Pacific Northwest contains about 30 percent of the employees, the Western Gulf 15 percent, the Ohio nearly 14 percent, the Tennessee and the Lower Mississippi 11 percent, the Eastern Great Lakes and St. Lawrence 7½ percent, the Eastern Arkansas-White-Red nearly 9 percent, and the Southeast region less than 2½ percent.

The above applies to the projections based upon RFF assumptions and also applies to the BDSA projections because the RFF Index of Industrial Production for the aluminum industry was considered realistic in this industry. (See tables 1 and 2.)

Copper.—In the base year 1954 nearly 40 percent of the employees in the primary copper industry were located in the Delaware and Hudson region, about 16 percent in the Great Basin region, 15 percent in the Colorado region, and 14 percent in the Rio Grande region. Two other regions were comparatively small in number of employees. Fifteen regions had no production in 1954 and the projections to 2000 show no estimated employment for those regions.

In the year 2000, based on RFF data, the relative rank with respect to employment is very similar to 1954. The Delaware and Hudson contains about 40 percent of the employees, nearly 16 percent in the Great Basin region, 15 percent in the Colorado region, and 14 percent in the Rio Grande region. (See table 1.)

Projections based on BDSA assumptions show almost the same pattern, although the number of employees in each case is about 50 percent as large. (See tables 1 and 2.)

METROPOLITAN AREAS

A study has been made with respect to each of the 37 selected metropolitan areas. Starting with the level of production obtained from the 1954 Census of Manufacturers, projections have been estimated for 1959, 1980, and 2000. Because of the varying natures of the industries and the different units of production, no combined tabulation was practical. However, the following comments are applicable.

In the case of food, chemicals, and pulp and paper industry groups, the production levels are presented in "value added in production" for the entire industry group. Data were not available by metropolitan areas for the establishments with water intake of 20 million gallons or more in 1954. The data therefore are not exactly comparable with the data given for the region in which a metropolitan area is located. Since levels include the smaller volume water users which in general purchase a high percentage of their requirements from the public water utilities, and it is recognized that the few large-volume water users located in metropolitan areas in all probability will self-supply their water requirements, it was not considered practical to prepare estimates of water used by these establishments. In most, but not all cases, the increase in levels of production present a rise similar to the estimated increase in production for the region in which the metropolitan area is located.

In the case of the three primary metal industries, pig iron and steel, primary aluminum and copper, data were rarely available on the value added in production, but the industry specialists were able to estimate the tonnage production for the specified years. Although those estimates of production encompass the entire industry, by coincidence, characteristic of these industries, all of the establishments included fall into the major water using group (20 million gallons or more in 1954), and accordingly it can be assumed that these establishments in nearly every case self-supply their own water requirements. Data were not available from which to identify the water intake by these four-digit code industries within these metropolitan areas. In most cases the estimated rate of increase of industrial production rises in close parallel with the estimated regional increase.

Although in national summary the establishments of these six specified industries represent a high percentage of the water intake by manufacturing industries, the pattern changes within a metropolitan area when the small-volume water users of all industries, large in number, are also included. These six industries' water requirements may in the case of many metropolitan areas represent a comparatively small percentage of the total industrial water furnished by the public water utility. Therefore to be meaningful, estimates must be prepared for all of the other industries before the demand upon public water utilities can be evaluated.

It is believed that when such estimates have been prepared encompassing all industries, they can be translated into number of industrial employees, which in turn can be translated into metropolitan population. The estimated projections can then be used to revise the previously prepared projections of population for the selected metropolitan areas.

COMMENTS

In general the water intake of these six specified industries for those establishments using 20 million gallons or more represents a high percentage of the total water intake for these industries. Thus the water intake of the smaller volume water users can be estimated with little effect upon the validity of the totals. The total requirements for those industries and including the petroleum and coal products industry group (which is being estimated by the Department of the Interior), represented 84 percent of the total water intake by manufacturing industries in 1954 and can be projected in approximately that ratio for future years.

With the data from the 1954 Census of Manufactures as a guide, it can be assumed that the larger water-using industrial establishments will self-supply in the neighborhood of 85 percent of their water requirements. The smaller volume water-using industrial establishments will more often locate in metropolitan areas and probably purchase 75 to 85 percent of their water requirements from the public water utilities.

Estimated projections have been presented for the industrial employees of the major water-using establishments of the six specified industries in each region. If estimates were included to cover the small-volume water-using establishments, and other industries, such estimates would then present the total industrial employment within each region. From this as a base, estimates can be prepared of the total urban increase of population for comparison with previously prepared projections of population for each of the 22 regions. After appropriate revision, the urban water requirements for domestic, commercial, industrial, and municipal use can be estimated, using appropriate trends of increase for future years.

Following the final assembly of the reports from the several Federal agencies, the aggregate water requirements in some regions may be found to exceed the economical potential development for providing the necessary firm minimum regulated stream-flow in the low-flow period. It may then be necessary to reduce the water requirements for some uses or shift industries into regions more favorable with respect to water supply.

Due to the trend of major water-using establishments away from self-generation of power, the large percentage of the total water intake now used for thermal generation will decrease in the future. However, this will not reduce the demand for electric power per unit of production; therefore will result in an increased demand for power from public electric utilities and the requisite water for this increased thermal generation. In other words a large percentage of future industrial power generation will be performed by public utilities rather than by industry itself.

Although there are variations among the major water-using establishments, in general about 67 percent practiced reuse in 1954. In so doing the total requirements were reduced by 44 percent. Reduction in the fresh water intake was also effected by the use of brackish water.

In future years, with water in some regions in short supply when compared with demand according to present-day technological practices, further reduction in water intake will be effected by more extensive reuse. Larger volume use of brackish water can effect additional reduction in fresh water requirements, especially for those industrial establishments located in coastal areas where tide water can be used in lieu of fresh water.

As a result of the above factors, additional reduction in water requirements can be applied in some of the overloaded regions before giving consideration to the hypothetical shift of some of the industries to other areas which are not as desirable in other respects.

No attempt has been made to evaluate the pollution problem which may ensue from the large increases in industrial production projected for future years. Projection according to present practice of industrial waste treatment would not be realistic and would impose theoretical limitations upon future industrial expansion. It is believed that when faced with the necessity for doing so, industries through research will develop methods of refinement of treatment which will produce within limitations effluents which will meet the criteria set up for each river basin or subbasin. Awakened as they are to this problem, industrial corporations will have these important considerations in the forefront when selecting sites for expansions or new plants.

With respect to the cost of water for industrial use, there is a wide variation. The major water-using establishments usually self-supply their requirements, attempting to hold the cost within the range of 5 to 10 cents per 1,000 gallons. On the other hand, the smaller volume water-using establishments which average only from 4 to 16 percent as much water, usually purchase from a public water utility at costs ranging from 12 to 20 cents per 1,000 gallons for larger volumes and from 20 to 28 cents per 1,000 gallons for the extremely small volume users. No comprehensive assembly has been made of these costs, but numerous articles in technical magazines have cited instances.

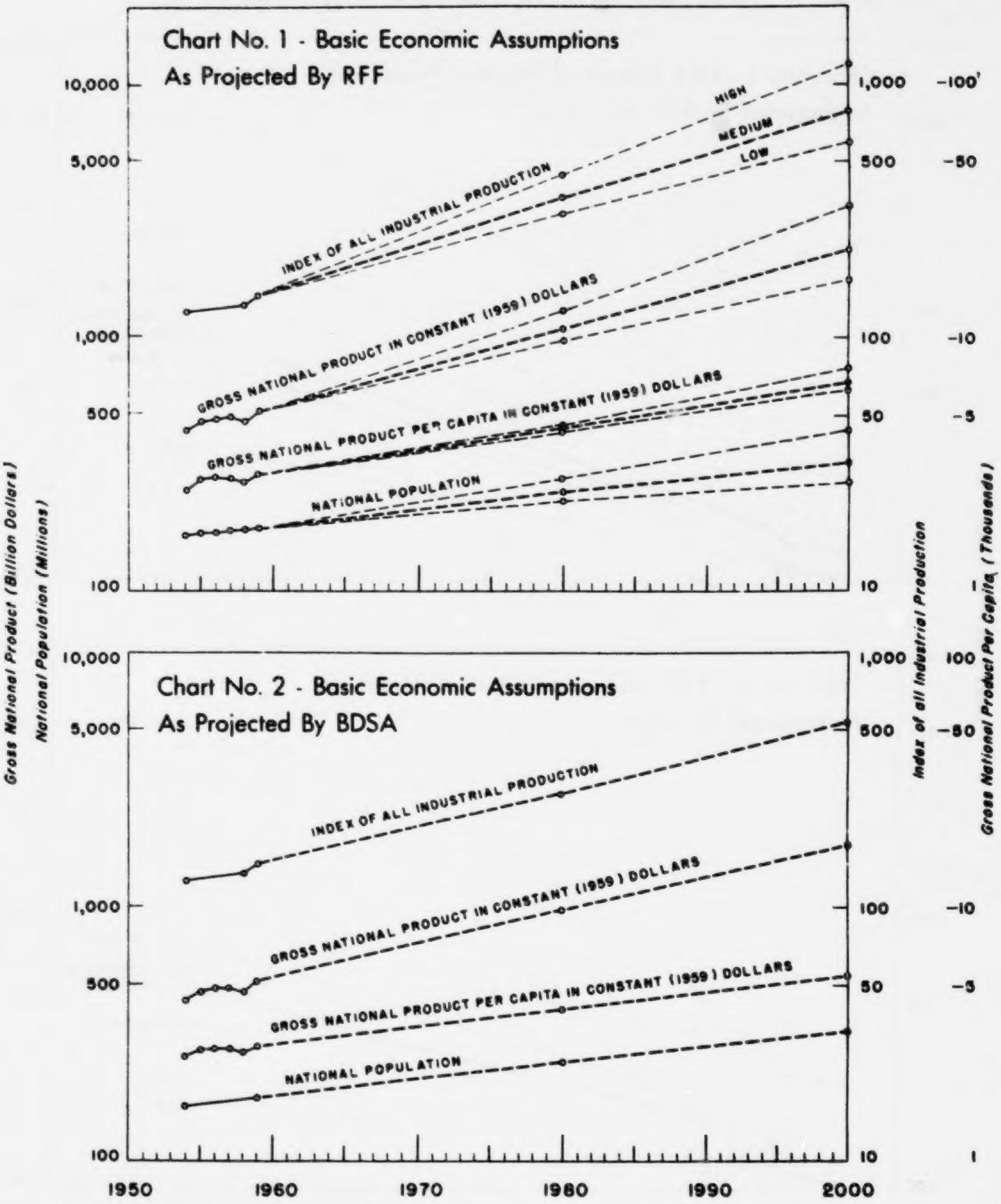
The actual consumption or depletion of water as a resource is indicated in the 1954 Census of Manufactures in the difference between the intake and the discharge of the manufacturing industries. In aggregate, such depletion is less than 10 percent of the total intake. In projections into the future it can be anticipated that as the requirements for fresh water intake are reduced by reuse, the percentage of depletion will increase. Tentatively it has been estimated that by 1980 the depletion may increase to more than 20 percent, largely due to evaporation to the atmosphere during recycling.

At the time of the initiation of this study the outcome of the steel and copper strikes was problematical, so a decision had to be made on whether this report on production and water requirements should reflect the impact of the disruption in those industries. Having no basis for projecting the extent and duration of these strikes and the impact on other industries if these strikes extended over a long period of time, it was decided to completely ignore both strikes and present these data on production, water requirements, and employment to reflect a hypothetical year 1959 as it should have been had these strikes not occurred.

APPENDIXES

APPENDIX A. SUMMARY CHARTS

Future Water Requirements 1954-2000
Principal Water-Using Manufacturing Industries



U.S. Department of Commerce, BDSA, Water and Sewerage Division

Reproduced from best available copy.

Future Water Requirements 1954-2000 Principal Water-Using Manufacturing Industries

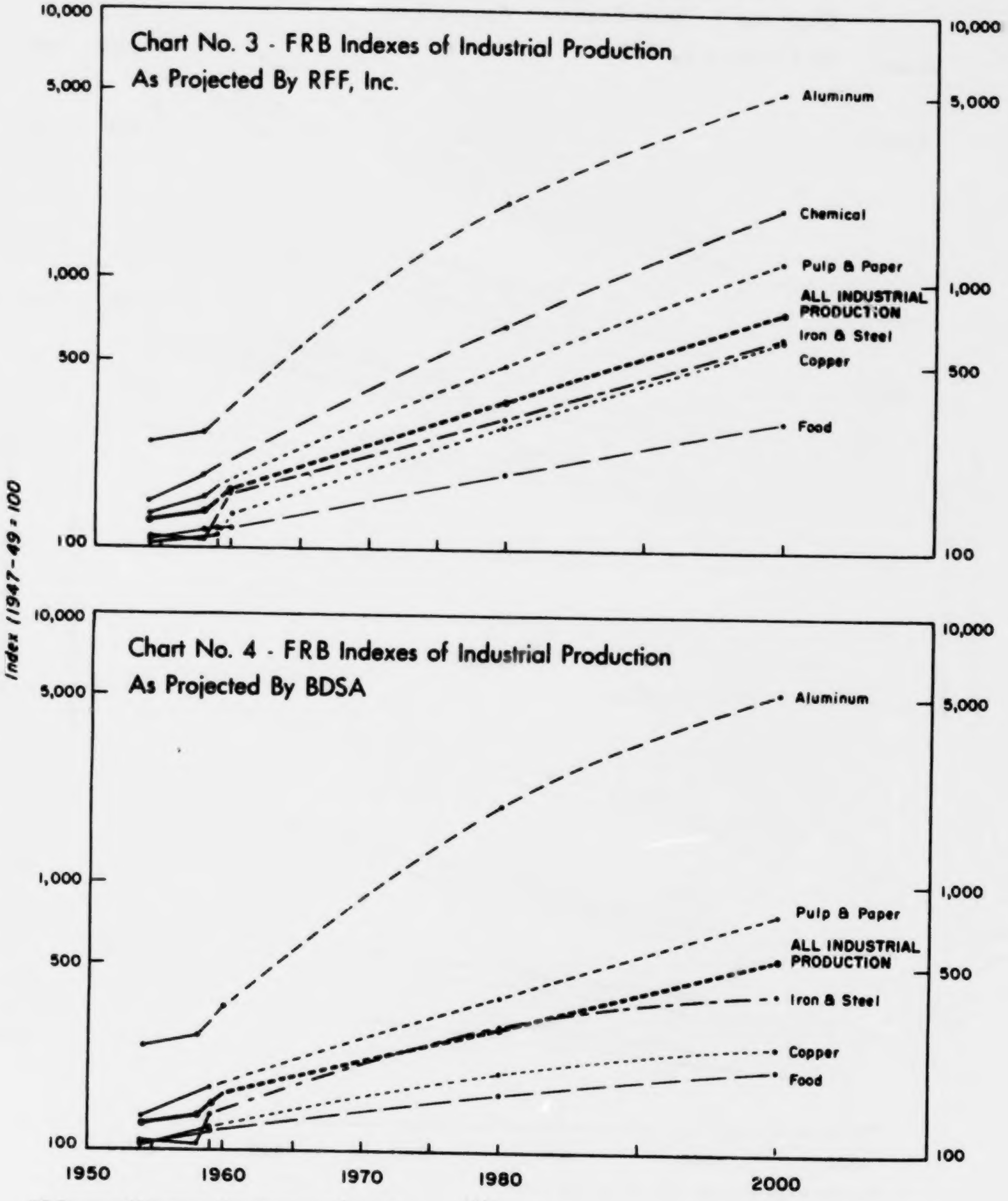
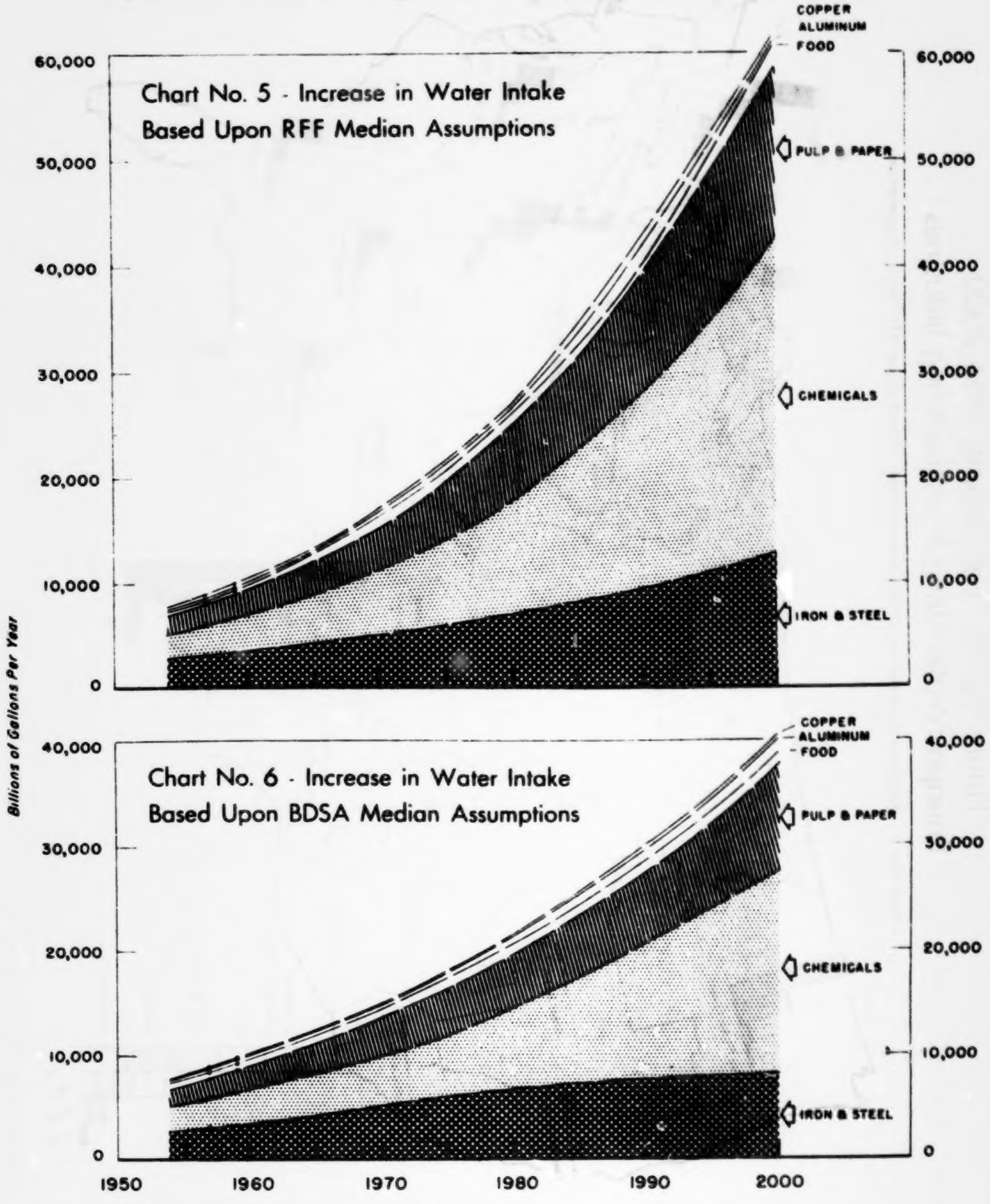


Chart No. 3 - FRB Indexes of Industrial Production As Projected By RFF, Inc.

Chart No. 4 - FRB Indexes of Industrial Production As Projected By BDSA

U.S. Department of Commerce, BDSA, Water and Sewerage Division

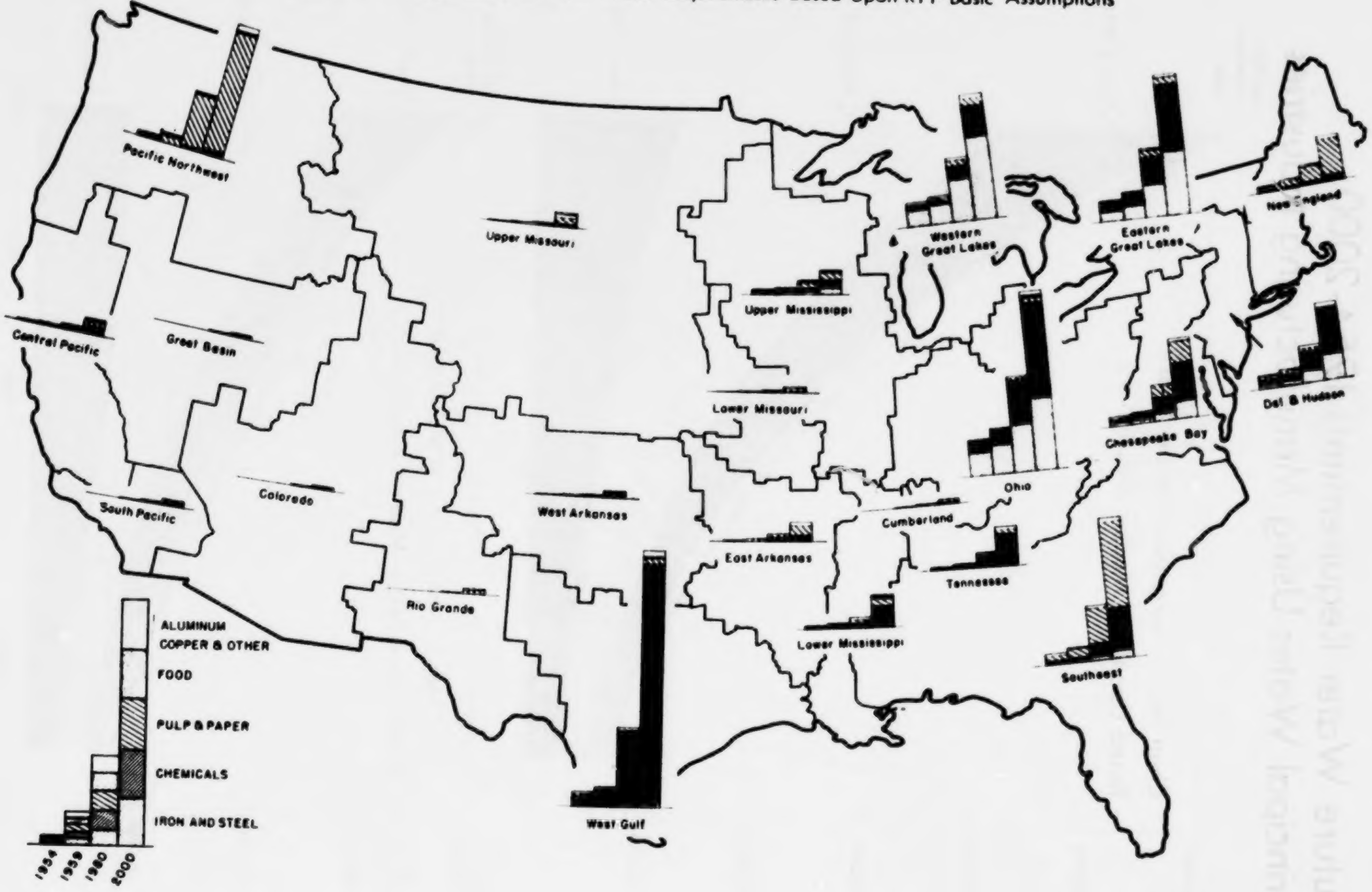
Future Water Requirements 1954-2000 Principal Water-Using Manufacturing Industries



U.S. Department of Commerce, BDSA, Water and Sewerage Division

Future Water Requirements 1954-2000
Principal Water-Using Manufacturing Industries

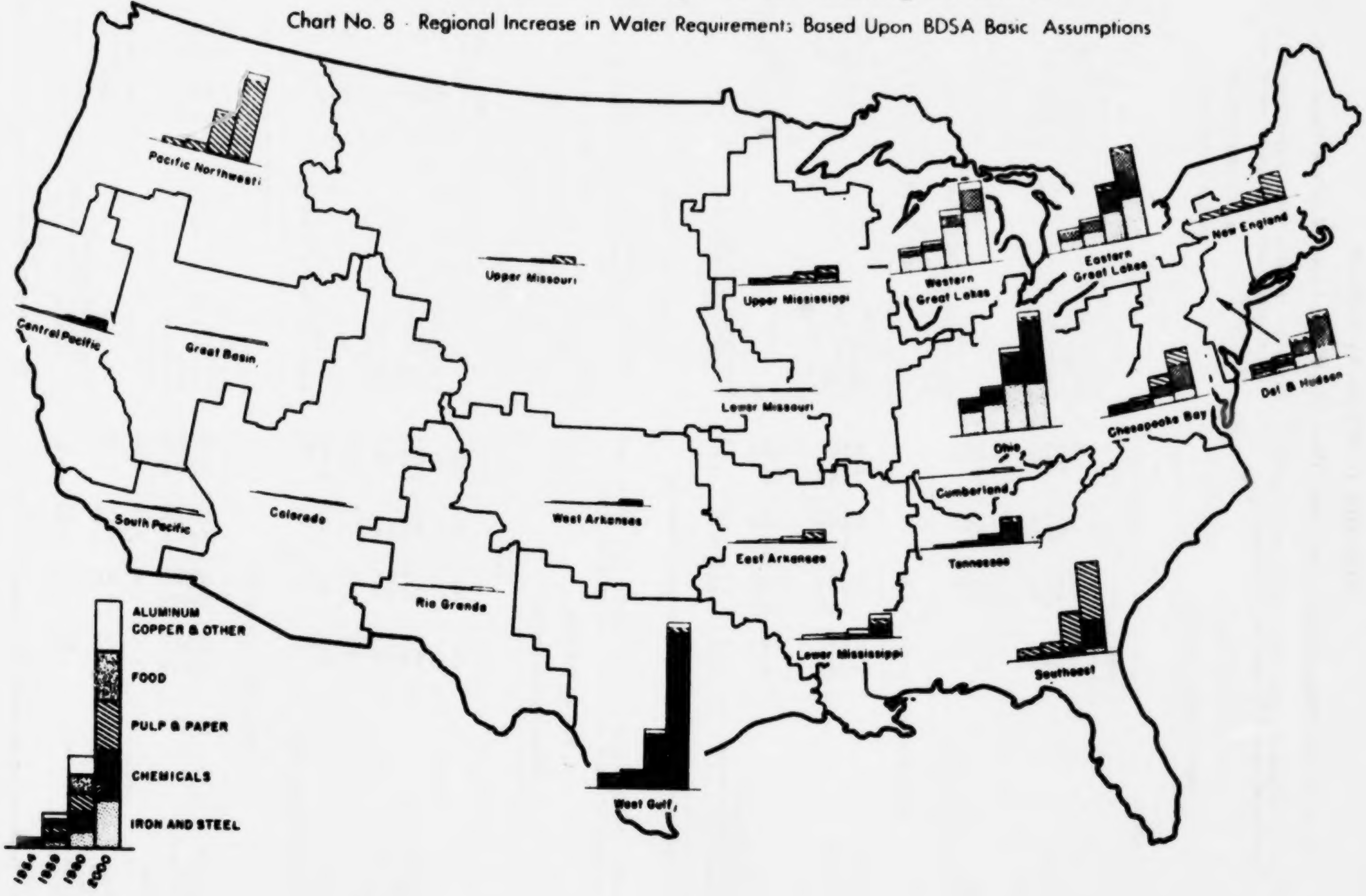
Chart No. 7 · Regional Increase in Water Requirements Based Upon RFF[1] Basic Assumptions


Pacific Northwest
Upper Missouri
Central Pacific
Great Basin
Upper Mississippi
Western Great Lakes
Eastern Great Lakes
New England
Del & Hudson
Chesapeake Bay
Ohio
Lower Missouri
Colorado
South Pacific
West Arkansas
Cumberland
East Arkansas
Tennessee
Rio Grande
Lower Mississippi
Southeast
West Gulf
ALUMINUM COPPER & OTHER
FOOD
PULP & PAPER
CHEMICALS
IRON AND STEEL
1954
1959
1980
2000

U.S. Department of Commerce, BDSA, Water and Sewerage Division

Future Water Requirements 1954-2000
Principal Water-Using Manufacturing Industries

Chart No. 8 - Regional Increase in Water Requirements Based Upon BDSA Basic Assumptions


Pacific Northwest
Central Pacific
Great Basin
South Pacific
Colorado
Rio Grande
Upper Missouri
West Arkansas
West Gulf
Upper Mississippi
Lower Missouri
East Arkansas
Lower Mississippi
Western Great Lakes
Eastern Great Lakes
Ohio
Cumberland
Tennessee
Southeast
Chesapeake Bay
Del & Hudson
New England
ALUMINUM COPPER & OTHER
FOOD
PULP & PAPER
CHEMICALS
IRON AND STEEL
1954
1960
1980
2000

U.S. Department of Commerce, BDSA, Water and Sewerage Division

APPENDIX B. SUMMARY TABLES

FUTURE WATER REQUIREMENTS, 1954–2000, PRINCIPAL WATER-USING MANUFACTURING INDUSTRIES

TABLE 7.—*New England region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	1.3	0.5	1.1	1.9
Chemical	41.0	52.0	135.0	260.0
Pulp and paper	249.0	331.0	767.0	1,703.0
Food	21.0	20.0	30.0	41.0
Aluminum				
Copper				
Total	312.3	403.5	933.1	2,005.9
Index	100	129	299	642
Billions of gallons, daily average	0.9	1.1	2.6	5.5

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	2,927	950	1,600	2,500
Chemical	14,000	15,000	28,000	59,000
Pulp and paper	38,000	51,000	117,000	260,000
Food	18,177	16,800	22,000	24,700
Aluminum				
Copper				
Total	73,104	83,750	168,600	346,200
Index	100	115	231	474
Water use per employee:				
Millions of gallons per year	4.3	4.8	5.5	5.8
Gallons per day	11,704	13,200	15,162	15,874

NOTE.—Details may not add to totals due to independent rounding.

TABLE 8.—*Delaware and Hudson region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	196.0	253.0	566.0	1,120.0
Chemical	237.0	308.0	864.0	1,920.0
Pulp and paper	93.0	102.0	106.0	96.0
Food	67.0	69.0	105.0	150.0
Aluminum				
Copper	25.0	28.6	72.3	158.2
Total	618.0	760.6	1,713.3	3,444.2
Index	100	123	277	557
Billions of gallons, daily average	1.7	2.1	4.7	9.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	41,218	43,500	80,000	134,000
Chemical	100,000	108,000	198,000	410,000
Pulp and paper	26,000	29,000	30,000	27,000
Food	100,716	102,000	136,500	169,000
Aluminum				
Copper	5,169	5,890	10,210	17,670
Total	273,103	288,390	454,710	757,670
Index	100	106	166	277
Water use per employee:				
Millions of gallons per year	2.3	2.6	3.8	4.5
Gallons per day	6,200	7,225	10,323	12,435

NOTE.—Details may not add to totals due to independent rounding.

TABLE 9.—*Eastern Great Lakes and St. Lawrence region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	486.0	646.0	1,449.0	2,862.0
Chemical	352.0	459.0	1,320.0	3,060.0
Pulp and paper	110.0	137.0	253.0	313.0
Food	23.0	25.0	40.0	61.0
Aluminum	3.6	4.2	22.8	58.8
Copper				
Total	974.6	1,271.2	3,084.8	6,354.8
Index	100.	130	317	652
Billions of gallons, daily average	2.7	3.5	8.5	17.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	67,433	73,200	134,000	240,000
Chemical	47,000	52,000	103,000	231,000
Pulp and paper	20,000	25,000	46,000	57,000
Food	35,351	37,800	55,000	73,450
Aluminum	2,252	2,600	7,000	14,500
Copper				
Total	172,036	190,600	345,000	615,950
Index	100	111	201	358
Water use per employee:				
Millions of gallons per year	5.7	6.7	8.9	10.3
Gallons per day	15,521	18,271	24,496	28,266

NOTE.—Details may not add to totals due to independent rounding.

TABLE 10.—*Chesapeake Bay region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	153	184	411	810
Chemical	144	194	636	1,710
Pulp and paper	109	174	563	994
Food	33	37	59	90
Aluminum				
Copper				
Total	439	589	1,669	3,604
Index	100	134	380	821
Billions of gallons, daily average	1.2	1.6	4.6	9.9

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	37,714	30,100	68,000	113,000
Chemical	30,000	32,000	62,000	136,000
Pulp and paper	14,000	22,000	72,000	128,000
Food	36,316	39,900	57,500	76,700
Aluminum				
Copper				
Total	118,030	124,000	259,500	453,700
Index	100	105	220	384
Water use per employee:				
Millions of gallons per year	3.7	4.8	6.4	7.9
Gallons per day	10,189	13,014	17,622	21,764

NOTE.—Details may not add to totals due to independent rounding.

TABLE 11.—*Western Great Lakes region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	738.0	866.0	1,917.0	3,742.0
Chemical	167.0	218.0	630.0	1,450.0
Pulp and paper	142.0	156.0	254.0	376.0
Food	69.0	73.0	114.0	174.0
Aluminum				
Copper	0.3	0.4	0.8	1.6
Total	1,116.3	1,313.4	2,915.8	5,743.6
Index	100	118	261	515
Billions of gallons daily average	3.1	3.6	8.0	15.7

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	79,524	75,200	138,000	228,000
Chemical	42,000	46,000	92,000	205,000
Pulp and paper	27,000	30,000	48,000	72,000
Food	94,317	100,100	141,500	183,950
Aluminum				
Copper	175	225	400	695
Total	243,016	251,525	419,900	689,645
Index	100	104	173	284
Water use per employee:				
Millions of gallons per year	4.6	5.2	6.9	8.3
Gallons per day	12,544	14,307	19,025	22,816

NOTE.—Details may not add to totals due to independent rounding.

TABLE 12.—*Ohio region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	1,034.0	1,302.0	2,217.0	3,209.0
Chemical	495.0	646.0	1,860.0	4,310.0
Pulp and paper	54.0	60.0	90.0	223.0
Food	46.0	50.0	77.0	112.0
Aluminum		10.4	81.0	186.1
Copper				
Total	1,629.0	2,068.4	4,325.0	8,040.1
Index	100	127	266	494
Billions of gallons daily average	4.5	5.7	11.8	22.0

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	212,630	217,550	305,000	373,000
Chemical	67,000	74,000	146,000	326,000
Pulp and paper	18,000	20,000	30,000	74,000
Food	61,757	65,800	92,000	117,000
Aluminum		2,700	13,400	27,700
Copper				
Total	359,387	380,050	586,400	917,700
Index	100	106	163	255
Water use per employee:				
Millions of gallons per year	4.5	5.4	7.4	8.8
Gallons per day	12,419	14,910	20,208	24,003

NOTE.—Details may not add to totals due to independent rounding.

TABLE 13.—*Cumberland region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel				
Chemical	14	18	53	120
Pulp and paper	2	13	44	108
Food	2	2	3	4
Aluminum				
Copper				
Total	18	33	100	232
Index	100	183	556	1,289
Billions of gallons daily average	0.1	0.1	0.3	0.6

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel				
Chemical	8,000	9,000	18,000	40,000
Pulp and paper		2,000	7,000	16,000
Food	1,500	1,400	2,000	1,950
Aluminum				
Copper				
Total	9,500	12,400	27,000	57,950
Index	100	131	284	610
Water use per employee:				
Millions of gallons per year	1.9	2.7	3.7	4.0
Gallons per day	5,189	7,290	10,148	10,967

NOTE.—Details may not add to totals due to independent rounding.

TABLE 14.—*Tennessee region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.2	0.4	0.7
Chemical	152.0	200.0	600.0	1,460.0
Pulp and paper	37.0	41.0	97.0	241.0
Food	3.0	3.0	4.0	5.0
Aluminum	5.6	9.0	35.1	91.3
Copper				
Total	197.8	253.2	736.5	1,798.0
Index	100	128	372	909
Billions of gallons daily average	0.5	0.7	2.0	4.9

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	489	400	700	1,000
Chemical	24,000	26,000	46,000	93,000
Pulp and paper	7,000	8,000	18,000	46,000
Food	3,900	3,780	5,000	5,200
Aluminum	3,515	3,866	10,900	22,500
Copper				
Total	38,904	42,046	80,600	167,700
Index	100	108	207	431
Water use per employee:				
Millions of gallons per year	5.1	6.0	9.1	10.7
Gallons per day	13,929	16,499	25,036	29,375

NOTE.—Details may not add to totals due to independent rounding.

Table 15.—*Southeast region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	62.0	74.0	190.0	412.0
Chemical	102.0	145.0	596.0	920.0
Pulp and paper	329.0	476.0	1,669.0	3,941.0
Food	40.0	43.0	67.0	102.0
Aluminum	1.2	1.3	7.3	18.8
Copper	------	------	------	------
Total	534.2	739.3	2,529.3	6,394.8
Index	100	138	473	1,197
Billions of gallons, daily average	1.5	2.0	6.9	17.5

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	21,870	21,000	45,000	82,000
Chemical	26,000	29,000	63,000	150,000
Pulp and paper	34,000	49,000	172,000	409,500
Food	33,472	35,700	50,000	65,000
Aluminum	780	800	2,200	4,690
Copper	------	------	------	------
Total	116,122	135,500	332,200	711,190
Index	100	117	286	612
Water use per employee:				
Millions of gallons per year	4.6	5.5	7.6	9.0
Gallons per day	12,603	14,948	20,855	24,636

NOTE.—Details may not adu to totals due to independent rounding.

Table 16.—*Upper Mississippi region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	74	94	185	308
Chemical	38	50	145	330
Pulp and paper	114	125	176	326
Food	86	89	134	188
Aluminum	------	------	------	------
Copper	------	------	------	------
Total	312	358	640	1,152
Index	100	115	205	369
Billions of gallons, daily average	0.9	1.0	1.8	3.2

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	10,304	10,500	17,000	24,000
Chemical	27,000	30,000	54,000	132,000
Pulp and paper	22,000	24,000	34,000	63,000
Food	96,098	98,700	132,000	162,500
Aluminum	------	------	------	------
Copper	------	------	------	------
Total	155,402	163,200	242,000	381,500
Index	100	105	156	245
Water use per employee:				
Millions of gallons per year	2.1	2.2	2.6	3.0
Gallons per day	5,599	6,011	7,247	8,274

NOTE.—Details may not add to totals due to independent rounding.

Table 17.—*Lower Mississippi region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	------	------	------	------
Chemical	41.0	60.0	273.0	940.0
Pulp and paper	31.0	34.0	73.0	364.0
Food	41.0	41.0	60.0	83.0
Aluminum	75.6	75.4	104.4	160.5
Copper	------	------	------	------
Total	188.6	210.4	510.4	1,547.5
Index	100	112	271	821
Billions of gallons, daily average	0.5	0.6	1.4	4.2

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	------	------	------	------
Chemical	13,000	14,000	31,000	76,000
Pulp and paper	6,000	7,000	14,000	70,000
Food	13,909	13,300	16,000	16,900
Aluminum	2,350	2,500	10,900	22,500
Copper	------	------	------	------
Total	35,259	36,800	71,900	185,400
Index	100	104	204	526
Water use per employee:				
Millions of gallons per year	5.3	5.7	7.1	8.3
Gallons per day	14,655	15,663	19,449	22,868

NOTE.—Details may not add to totals due to independent rounding.

Table 18.—*Upper Missouri region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	------	------	------	------
Chemical	10.0	13.0	42.0	110.0
Pulp and paper	------	------	------	300.0
Food	50.0	50.0	74.0	105.0
Aluminum	------	------	------	------
Copper	2.3	2.8	5.5	11.7
Total	62.3	65.8	121.5	526.7
Index	100	105	195	845
Billions of gallons, daily average	0.2	0.2	0.3	1.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	------	------	------	------
Chemical	8,000	9,000	20,000	50,000
Pulp and paper	------	------	------	60,000
Food	37,604	36,400	46,000	52,650
Aluminum	------	------	------	------
Copper	350	440	700	1,315
Total	45,954	45,840	66,700	163,965
Index	100	100	145	357
Water use per employee:				
Millions of gallons per year	1.4	1.4	1.8	3.2
Gallons per day	3,721	3,932	4,986	8,800

NOTE.—Details may not add to totals due to independent rounding.

TABLE 19.—*Lower Missouri region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	10.0	10.4	19.6	32.4
Chemical	1.0	1.0	3.0	9.0
Pulp and paper	10.0	12.0	40.0	200.0
Food	10.0	9.0	13.0	18.0
Aluminum				
Copper				
Total	31.0	32.4	75.6	259.4
Index	100	105	244	837
Billions of gallons daily average	.1	.1	.2	.7

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	2,113	1,800	2,800	3,900
Chemical	1,000	1,000	2,000	5,000
Pulp and paper	2,000	2,000	8,000	40,000
Food	9,951	9,100	11,000	11,440
Aluminum				
Copper				
Total	15,064	13,900	23,800	60,340
Index	100	92	158	401
Water use per employee:				
Millions of gallons per year	2.1	2.3	3.2	4.3
Gallons per day	5,638	6,386	8,701	11,778

NOTE.—Details may not add to totals due to independent rounding.

TABLE 20.—*Eastern Arkansas-White-Red region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	7.0	10.0	17.5	28.4
Chemical	29.0	38.0	114.0	270.0
Pulp and paper	56.0	62.0	168.0	414.0
Food	4.0	4.0	5.0	5.0
Aluminum	57.7	57.0	80.1	122.8
Copper				
Total	153.7	171.0	384.6	840.2
Index	100	111	250	547
Billions of gallons daily average	.4	.5	1.1	2.3

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	3,261	3,700	5,700	7,700
Chemical	7,000	8,000	16,000	36,000
Pulp and paper	11,000	12,000	33,000	82,000
Food	5,738	5,250	5,500	5,200
Aluminum	2,480	2,500	8,450	17,200
Copper				
Total	29,479	31,450	68,650	148,100
Index	100	107	233	502
Water use per employee:				
Millions of gallons per year	5.2	5.4	5.6	5.7
Gallons per day	14,285	14,806	15,348	15,542

NOTE.—Details may not add to totals due to independent rounding.

TABLE 21.—*Western Arkansas-White-Red region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	15.0	17.0	31.3	53.5
Chemical	8.0	12.0	54.0	180.0
Pulp and paper				203.0
Food	8.0	8.0	11.0	16.0
Aluminum				
Copper				
Total	31.0	37.0	96.3	352.5
Index	100	119	311	1,137
Billions of gallons daily average	0.1	0.1	0.3	1.0

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	9,711	8,700	14,000	20,000
Chemical	3,000	3,000	6,000	16,000
Pulp and paper				20,000
Food	8,370	8,400	10,500	12,350
Aluminum				
Copper				
Total	21,081	20,100	30,500	68,350
Index	100	95	145	324
Water use per employee:				
Millions of gallons per year	1.5	1.8	3.2	5.2
Gallons per day	4,030	5,040	8,649	14,129

NOTE.—Details may not add to totals due to independent rounding.

TABLE 22.—*Western gulf region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	21.1	25.0	62.4	136.0
Chemical	471.0	693.0	3,150.0	10,800.0
Pulp and paper	29.0	41.0	132.0	[illegible]
Food	13.0	15.0	25.0	[illegible]
Aluminum	108.1	108.0	181.0	265.2
Copper				
Total	642.2	882.0	3,550.4	11,565.2
Index	100	137	553	1,801
Billions of gallons daily average	1.8	2.4	9.7	31.7

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	6,078	5,800	12,000	23,000
Chemical	27,000	31,000	67,000	161,000
Pulp and paper	4,000	6,000	18,000	45,000
Food	18,542	20,650	31,500	41,730
Aluminum	3,898	4,100	14,200	30,000
Copper				
Total	59,518	67,550	142,700	300,730
Index	100	113	240	505
Water use per employee:				
Millions of gallons per year	10.8	13.1	24.9	38.5
Gallons per day	29,562	35,775	68,164	105,362

NOTE.—Details may not add to totals due to independent rounding.

TABLE 23.—*Rio Grande region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	--------	--------	--------	--------
Chemical	1.0	1.0	3.0	10.0
Pulp and paper	--------	--------	--------	170.0
Food	--------	--------	1.0	2.0
Aluminum	--------	--------	--------	--------
Copper	7.0	8.4	16.5	34.6
Total	8.0	9.4	20.5	216.6
Index	100	118	256	2,708
Billions of gallons, daily average	0.1	0.1	0.1	0.6

B. NUMBER OF EMPLOYEES

Iron and steel	--------	--------	--------	--------
Chemical	50	50	100	220
Pulp and paper	--------	--------	--------	21,000
Food	1,036	1,120	1,800	2,730
Aluminum	--------	--------	--------	--------
Copper	1,850	2,100	3,640	6,300
Total	2,936	3,270	5,540	30,250
Index	100	111	189	1,030
Water use per employee:				
Millions of gallons per year	2.7	2.9	3.7	7.2
Gallons per day	7,466	7,877	10,137	19,616

NOTE.—Details may not add to totals due to independent rounding.

TABLE 24.—*Colorado region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	--------	--------	0.1	0.2
Chemical	1.0	1.0	3.0	9.0
Pulp and paper	.5	1.0	2.0	135.0
Food	2.0	3.0	5.0	8.0
Aluminum	--------	--------	--------	--------
Copper	1.0	1.2	2.0	4.4
Total	4.5	6.2	12.1	156.6
Index	100	138	269	3,480
Billions of gallons, daily average	0.1	0.1	0.1	0.4

B. NUMBER OF EMPLOYEES

Iron and steel	--------	200	400	600
Chemical	50	50	100	220
Pulp and paper	--------	--------	--------	27,000
Food	1,900	2,100	4,000	6,500
Aluminum	--------	--------	--------	--------
Copper	2,014	2,295	3,980	6,890
Total	3,964	4,645	8,480	41,210
Index	100	117	214	1,040
Water use per employee:				
Millions of gallons per year	1.1	1.3	1.4	3.8
Gallons per day	3,110	3,658	3,910	10,411

NOTE.—Details may not add to totals due to independent rounding.

TABLE 25.—*Pacific Northwest region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.3	5.1	9.7
Chemical	27.0	36.0	112.0	290.0
Pulp and paper	224.0	354.0	2,401.0	5,494.0
Food	23.0	26.0	43.0	70.0
Aluminum	11.0	15.0	93.6	245.4
Copper	2.2	2.6	7.5	14.0
Total	287.4	433.9	2,662.2	6,123.1
Index	100	151	926	2,131
Billions of gallons, daily average	0.8	1.2	7.3	16.8

B. NUMBER OF EMPLOYEES

Iron and steel	1,475	1,200	2,100	3,400
Chemical	3,000	3,000	8,000	19,000
Pulp and paper	17,000	27,000	182,000	417,000
Food	19,378	21,700	32,000	45,500
Aluminum	5,693	5,800	29,000	60,000
Copper	1,450	1,650	2,850	4,930
Total	47,996	60,350	255,950	549,830
Index	100	126	533	1,146
Water use per employee:				
Millions of gallons per year	6.0	7.2	10.4	11.1
Gallons per day	16,405	19,699	28,496	30,510

NOTE.—Details may not add to totals due to independent rounding.

TABLE 26.—*Great Basin region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	11.3	12.9	26.4	45.4
Chemical	4.0	5.0	16.0	42.0
Pulp and paper	0.5	1.0	2.0	68.0
Food	2.0	2.0	5.0	8.0
Aluminum	--------	--------	--------	--------
Copper	4.3	5.1	10.5	22.5
Total	22.1	26.0	59.9	185.9
Index	100	118	271	841
Billions of gallons, daily average	0.1	0.1	0.2	0.5

B. NUMBER OF EMPLOYEES

Iron and steel	9,637	8,900	14,000	21,000
Chemical	1,000	2,000	4,000	9,000
Pulp and paper	--------	--------	--------	14,000
Food	2,448	2,800	5,200	8,190
Aluminum	--------	--------	--------	--------
Copper	2,100	2,400	4,160	7,200
Total	15,185	16,100	27,360	59,390
Index	100	106	180	391
Water use per employee:				
Millions of gallons per year	1.5	1.6	2.2	3.1
Gallons per day	3,986	4,425	5,997	8,575

NOTE.—Details may not add to totals due to independent rounding.

TABLE 27.—*Central Pacific region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.2	11.0	24.3
Chemical	33.0	44.0	144.0	380.0
Pulp and paper	13.0	14.0	36.0	177.0
Food	34.0	44.0	92.0	162.0
Aluminum				
Copper				
Total	80.2	102.2	283.0	743.3
Index	100	127	353	927
Billions of gallons daily average	0.2	0.3	0.8	2.0

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	4,077	3,600	8,000	15,000
Chemical	6,000	7,000	16,000	40,000
Pulp and paper	3,000	3,000	11,000	52,000
Food	38,982	50,400	95,000	144,300
Aluminum				
Copper				
Total	52,059	64,000	130,000	251,300
Index	100	123	250	483
Water use per employee:				
Million gallons per year	1.5	1.6	2.2	3.0
Gallons per day	4,222	4,375	5,964	8,104

NOTE.—Details may not add to totals due to independent rounding.

TABLE 28.—*South Pacific region water intake and employment based upon RFF median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	2.6	4.5	13.8	30.0
Chemical	10.0	13.0	42.0	110.0
Pulp and paper	4.0	6.0	20.0	101.0
Food	13.0	17.0	33.0	58.0
Aluminum				
Copper				
Total	29.6	40.5	108.8	299.0
Index	100	137	368	1,010
Billions of gallons daily average	0.1	0.1	0.3	0.8

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	8,229	11,500	24,000	43,000
Chemical	5,000	6,000	13,000	33,000
Pulp and paper	2,000	3,000	6,000	30,000
Food	21,272	27,300	48,800	73,060
Aluminum				
Copper				
Total	36,501	47,800	91,800	179,060
Index	100	131	251	491
Water use per employee:				
Millions of gallons per year	0.8	0.8	1.2	1.7
Gallons per day	2,222	2,321	3,247	4,575

NOTE.—Details may not add to totals due to independent rounding.

TABLE 29.—*New England region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	1.3	0.5	1.0	1.2
Chemical	41.0	52.0	101.0	170.0
Pulp and paper	249.0	331.0	588.0	1,106.0
Food	21.0	20.0	26.0	28.0
Aluminum				
Copper				
Total	312.3	403.5	716.0	1,305.2
Index	100	129	229	418
Billions of gallons, daily average	0.9	1.1	2.0	3.6

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	2,927	950	1,550	1,600
Chemical	14,000	15,000	23,000	41,000
Pulp and paper	38,000	51,000	90,000	169,000
Food	18,177	16,800	19,800	19,950
Aluminum				
Copper				
Total	73,104	83,750	134,350	231,550
Index	100	115	184	317
Water use per employee:				
Millions of gallons per year	4.3	4.8	5.3	5.6
Gallons per day	11,704	13,200	14,600	15,444

NOTE.—Details may not add to totals due to independent rounding.

TABLE 30.—*Delaware and Hudson region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	196.0	253.0	544.0	717.0
Chemical	237.0	308.0	643.0	1,250.0
Pulp and paper	93.0	102.0	106.0	96.0
Food	67.0	69.0	89.0	100.0
Aluminum				
Copper	25.0	28.6	49.8	67.0
Total	618.0	760.6	1,431.8	2,230.0
Index	100	123	232	361
Billions of gallons, daily average	1.7	2.1	3.9	6.1

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	41,218	43,500	76,700	85,500
Chemical	100,000	108,000	162,000	285,000
Pulp and paper	26,000	29,000	30,000	27,000
Food	100,716	102,000	123,650	136,500
Aluminum				
Copper	5,169	5,890	8,540	10,200
Total	273,103	288,390	400,890	544,200
Index	100	106	147	199
Water use per employee:				
Millions of gallons per year	2.3	2.6	3.6	4.1
Gallons per day	6,200	7,225	9,786	11,227

NOTE.—Details may not add to totals due to independent rounding.

TABLE 31.—*Eastern Great Lakes and St. Lawrence region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	486.0	646.0	1,391.0	1,832.0
Chemical	352.0	459.0	987.0	1,990.0
Pulp and paper	110.0	137.0	194.0	203.0
Food	23.0	25.0	34.0	41.0
Aluminum	3.6	4.2	22.8	58.0
Copper				
Total	974.6	1,271.2	2,628.8	4,124.0
Index	100	130	270	423
Billions of gallons, daily average	2.7	3.5	7.2	11.3

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	67,433	73,200	128,800	143,500
Chemical	47,000	52,000	85,000	161,000
Pulp and paper	20,000	25,000	35,000	37,000
Food	35,351	37,800	49,500	59,300
Aluminum	2,252	2,600	7,000	14,500
Copper				
Total	172,036	190,600	305,300	415,300
Index	100	111	177	241
Water use per employee:				
Millions of gallons per year	5.7	6.7	8.6	9.9
Gallons per day	15,521	18,271	23,592	27,205

NOTE.—Details may not add to totals due to independent rounding.

TABLE 32.—*Chesapeake Bay region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	153	184	394	519
Chemical	144	194	474	1,110
Pulp and paper	109	174	432	646
Food	33	[illegible]	50	60
Aluminum				
Copper				
Total	439	589	1,350	2,335
Index	100	134	308	532
Billions of gallons, daily average	1.2	1.6	3.7	6.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	37,714	30,100	65,000	72,300
Chemical	30,000	32,000	51,000	95,000
Pulp and paper	14,000	22,000	55,000	83,000
Food	36,316	39,900	51,750	62,000
Aluminum				
Copper				
Total	118,030	124,000	222,750	312,300
Index	100	105	189	265
Water use per employee:				
Millions of gallons per year	3.7	4.8	6.1	7.5
Gallons per day	10,189	13,014	16,605	20,485

NOTE.—Details may not add to totals due to independent rounding.

TABLE 33.—*Western Great Lakes region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	738.0	866.0	1,840.0	2,395.0
Chemical	167.0	218.0	468.0	944.0
Pulp and paper	142.0	156.0	195.0	244.0
Food	69.0	73.0	99.0	115.0
Aluminum				
Copper	.3	.4	.5	.5
Total	1,116.3	1,313.4	2,602.5	3,698.5
Index	100	118	233	331
Billions of gallons, daily average	3.1	3.6	7.1	10.1

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	79,524	75,200	132,400	145,700
Chemical	42,000	46,000	75,000	142,000
Pulp and paper	27,000	30,000	37,000	47,000
Food	94,317	100,100	127,350	148,550
Aluminum				
Copper	175	225	300	325
Total	243,016	251,525	372,050	483,575
Index	100	104	153	199
Water use per employee:				
Millions of gallons per year	4.6	5.2	7.0	7.6
Gallons per day				20,953

NOTE.—Details may not add to totals due to independent rounding.

TABLE 34.—*Ohio region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	1,034.0	1,302.0	2,128.0	2,054.0
Chemical	495.0	646.0	1,390.0	2,800.0
Pulp and paper	54.0	60.0	69.0	145.0
Food	46.0	50.0	66.0	75.0
Aluminum		10.4	81.0	186.1
Copper				
Total	1,629.0	2,068.4	3,734.0	5,260.1
Index	100	127	229	323
Billions of gallons, daily average	4.5	5.7	10.2	14.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	212,630	217,550	292,800	239,000
Chemical	67,000	74,000	119,000	226,000
Pulp and paper	18,000	20,[illegible]	23,000	48,000
Food	61,757	65,800	82,800	94,500
Aluminum		2,700	13,400	27,700
Copper				
Total	359,387	380,050	531,000	635,200
Index	100	106	148	177
Water use per employee:				
Millions of gallons per year	4.5	5.4	7.0	8.3
Gallons per day	12,419	14,910	19,266	22,688

NOTE.—Details may not add to totals due to independent rounding.

TABLE 35.—*Cumberland region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel				
Chemical	--------	--------	--------	--------
Pulp and paper	14	18	39	79
Food	2	13	34	70
Aluminum	2	2	2	2
Copper	--------	--------	--------	--------
	--------	--------	--------	--------
Total	18	33	75	151
Index	100	183	417	839
Billions of gallons, daily average	0.1	0.1	0.2	0.4

B. NUMBER OF EMPLOYEES

Iron and steel				
Chemical	--------	--------	--------	--------
Pulp and paper	8,000	9,000	15,000	28,000
Food	--------	2,000	5,000	10,000
Aluminum	1,500	1,400	1,800	1,600
Copper	--------	--------	--------	--------
	--------	--------	--------	--------
Total	9,500	12,400	21,800	39,600
Index	100	131	229	417
Water use per employee:				
Millions of gallons per year	1.9	2.7	3.4	3.8
Gallons per day	5,189	7,290	9,425	10,447

NOTE.—Details may not add to totals due to independent rounding.

TABLE 36.—*Tennessee region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.2	0.4	0.5
Chemical	152.0	200.0	447.0	951.0
Pulp and paper	37.0	41.0	74.0	157.0
Food	3.0	3.0	3.0	3.0
Aluminum	5.6	9.0	35.1	91.3
Copper	--------	--------	--------	--------
Total	197.8	253.2	559.5	1,202.8
Index	100	128	283	608
Billions of gallons, daily average	0.5	0.7	1.5	3.3

B. NUMBER OF EMPLOYEES

Iron and steel	489	400	630	650
Chemical	24,000	26,000	38,000	65,000
Pulp and paper	7,000	8,000	14,000	30,000
Food	3,900	3,780	4,500	4,200
Aluminum	3,515	3,866	10,900	22,500
Copper	--------	--------	--------	--------
Total	38,904	42,046	68,030	122,350
Index	100	108	175	314
Water use per employee:				
Millions of gallons per year	5.1	6.0	8.2	9.8
Gallons per day	13,929	16,499	22,532	26,934

NOTE.—Details may not add to totals due to independent rounding.

TABLE 37.—*Southeast region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	62.0	74.0	182.0	264.0
Chemical	102.0	145.0	444.0	125.0
Pulp and paper	329.0	476.0	1,281.0	2,560.0
Food	40.0	43.0	57.0	68.0
Aluminum	1.2	1.3	7.3	21.8
Copper	--------	--------	--------	--------
Total	534.2	739.3	1,971.3	4,163.8
Index	100	138	369	779
Billions of gallons, daily average	1.5	2.0	5.4	11.4

B. NUMBER OF EMPLOYEES

Iron and steel	21,870	21,000	42,800	52,500
Chemical	26,000	29,000	51,000	104,000
Pulp and paper	34,000	49,000	132,000	263,700
Food	33,472	35,700	45,000	52,500
Aluminum	780	800	2,260	4,630
Copper	--------	--------	--------	--------
Total	116,122	135,500	273,060	477,330
Index	100	117	235	411
Water use per employee:				
Millions of gallons per year	4.6	5.5	7.2	8.7
Gallons per day	12,603	14,948	19,778	23,899

NOTE.—Details may not add to totals due to independent rounding.

TABLE 38.—*Upper Mississippi region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	74	94	177	197
Chemical	38	50	106	214
Pulp and paper	114	125	135	212
Food	86	89	114	125
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	312	358	532	748
Index	100	115	171	240
Billions of gallons, daily average	0.9	1.0	1.5	2.0

B. NUMBER OF EMPLOYEES

Iron and steel	10,304	10,500	16,500	15,500
Chemical	27,000	30,000	48,000	92,000
Pulp and paper	22,000	24,000	26,000	41,000
Food	96,098	98,700	118,800	131,250
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	155,402	163,200	209,300	279,750
Index	100	105	135	180
Water use per employee:				
Millions of gallons per year	2.1	2.2	2.5	2.7
Gallons per day	5,499	6,011	6,964	7,326

NOTE.—Details may not add to totals due to independent rounding.

TABLE 39.—*Lower Mississippi region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	----	----	----	----
Chemical	41.0	60.0	204.0	608.0
Pulp and paper	31.0	34.0	56.0	236.0
Food	41.0	41.0	51.0	55.0
Aluminum	75.6	75.4	104.4	160.5
Copper	----	----	----	----
Total	188.6	210.4	415.4	1,059.5
Index	100	112	220	562
Billions of gallons, daily average	0.5	0.6	1.1	2.9

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	----	----	----	----
Chemical	13,000	14,000	26,000	52,000
Pulp and paper	6,000	7,000	11,000	45,000
Food	13,909	13,300	14,400	13,650
Aluminum	2,350	2,500	10,900	22,500
Copper	----	----	----	----
Total	35,259	36,800	62,300	133,150
Index	100	104	177	378
Water use per employee:				
Millions of gallons per year	5.3	5.7	6.7	8.0
Gallons per day	14,655	15,663	18,268	21,800

NOTE.—Details may not add to totals due to independent rounding.

TABLE 40.—*Upper Missouri region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	----	----	----	----
Chemical	10.0	13.0	31.0	71.0
Pulp and paper	----	----	----	195.0
Food	50.1	50.0	63.0	70.0
Aluminum	----	----	----	----
Copper	2.3	2.8	3.8	4.1
Total	62.4	65.8	97.8	340.1
Index	100	105	157	545
Billions of gallons, daily average	0.2	0.2	0.3	0.9

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	----	----	----	----
Chemical	8,000	9,000	16,000	35,000
Pulp and paper	----	----	----	39,000
Food	37,604	36,400	41,400	42,500
Aluminum	----	----	----	----
Copper	350	440	500	550
Total	45,954	45,840	57,900	117,050
Index	100	100	126	255
Water use per employee:				
Millions of gallons per year	1.4	1.4	1.7	2.9
Gallons per day	3,721	3,932	4,627	7,962

NOTE.—Details may not add to totals due to independent roundings

TABLE 41.—*Lower Missouri region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	10.0	10.4	18.8	20.7
Chemical	1.0	1.0	2.0	6.0
Pulp and paper	10.0	12.0	31.0	130.0
Food	10.0	9.0	11.0	12.0
Aluminum	----	----	----	----
Copper	----	----	----	----
Total	31.0	32.4	62.8	168.7
Index	100	105	203	544
Billions of gallons, daily average	0.1	0.1	0.2	0.5

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	2,113	1,800	2,600	2,500
Chemical	1,000	1,000	2,000	4,000
Pulp and paper	2,000	2,000	6,000	26,000
Food	9,951	9,100	9,900	9,250
Aluminum	----	----	----	----
Copper	----	----	----	----
Total	15,064	13,900	20,500	41,750
Index	100	92	136	277
Water use per employee:				
Millions of gallons per year	2.1	2.3	3.1	4.0
Gallons per day	5,638	6,386	8,392	11,071

NOTE.—Details may not add to totals due to independent rounding.

TABLE 42.—*Eastern Arkansas-White-Red region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	7.0	10.0	16.8	18.1
Chemical	29.0	38.0	85.0	179.0
Pulp and paper	56.0	62.0	129.0	269.0
Food	4.0	4.0	4.0	4.0
Aluminum	57.7	57.0	80.1	122.0
Copper	----	----	----	----
Total	153.7	171.0	314.9	592.1
Index	100	111	205	385
Billions of gallons, daily average	0.4	0.5	0.9	1.6

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	3,261	3,700	5,400	4,900
Chemical	7,000	8,000	13,000	25,000
Pulp and paper	11,000	12,000	25,000	53,000
Food	5,738	5,250	4,950	4,200
Aluminum	2,480	2,500	8,450	17,200
Copper	----	----	----	----
Total	29,479	31,450	56,800	104,300
Index	100	107	193	354
Water use per employee:				
Millions of gallons per year	5.2	5.4	5.5	5.7
Gallons per day	14,285	14,896	15,189	15,553

NOTE.—Details may not add to totals due to independent rounding.

TABLE 43.—*Western Arkansas-White-Red region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	15.0	17.0	30.1	34.2
Chemical	8.0	12.0	40.0	120.0
Pulp and paper	--------	--------	--------	67.0
Food	8.0	8.0	9.0	11.0
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	31.0	37.0	79.1	232.2
Index	100	119	255	749
Billions of gallons daily average	0.1	0.1	0.2	0.6

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	9,711	8,700	13,500	13,000
Chemical	3,000	3,000	5,000	11,000
Pulp and paper	--------	--------	--------	13,000
Food	8,370	8,400	9,450	10,000
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	21,081	20,100	27,950	47,000
Index	100	95	133	223
Water use per employee:				
Millions of gallons per year	1.5	1.8	2.8	4.9
Gallons per day	4,030	5,044	7,753	13,534

NOTE.—Details may not add to totals due to independent rounding.

TABLE 44.—*Western Gulf region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	21.1	25.1	59.8	87.1
Chemical	471.0	693.0	2,340.0	7,010.0
Pulp and paper	29.0	41.0	101.0	212.0
Food	13.0	15.0	21.0	26.0
Aluminum	108.1	108.1	181.0	255.2
Copper	--------	--------	--------	--------
Total	642.2	882.1	2,702.8	7,590.3
Index	100	137	421	1,182
Billions of gallons, daily average	1.8	2.4	7.4	20.8

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	6,078	5,800	11,800	14,500
Chemical	27,000	31,000	55,000	112,000
Pulp and paper	4,000	6,000	14,000	29,000
Food	18,542	20,650	28,350	33,700
Aluminum	3,898	4,100	14,200	30,000
Copper	--------	--------	--------	--------
Total	59,518	67,550	123,350	219,200
Index	100	113	207	368
Water use per employee:				
Millions of gallons per year	10.8	13.1	21.9	34.6
Gallons per day	29,562	35,775	60,033	94,868

NOTE.—Details may not add to totals due to independent rounding.

TABLE 45.—*Rio Grande region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	--------	--------	--------	--------
Chemical	1.0	1.0	2.0	6.0
Pulp and paper	--------	--------	--------	110.0
Food	--------	--------	1.0	1.0
Aluminum	--------	--------	--------	--------
Copper	7.0	8.4	11.0	12.0
Total	8.0	9.4	14.0	129.0
Index	100	118	175	1,613
Billions of gallons daily average	0.1	0.1	0.1	0.4

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	--------	--------	--------	--------
Chemical	50	50	80	150
Pulp and paper	--------	--------	--------	14,000
Food	1,036	1,120	1,620	2,200
Aluminum	--------	--------	--------	--------
Copper	1,850	2,100	2,500	3,100
Total	2,936	3,270	4,200	19,450
Index	100	111	143	662
Water use per employee:				
Millions of gallons per year	2.7	2.9	3.3	6.6
Gallons per day	7,466	7,877	9,132	18,170

NOTE.—Details may not add to totals due to independent rounding.

TABLE 46.—*Colorado region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years 1954	1959	1980	2000
Iron and steel	--------	--------	--------	--------
Chemical	1.0	1.0	2.0	6.0
Pulp and paper	0.5	1.0	2.0	88.0
Food	2.0	3.0	4.0	6.0
Aluminum	--------	--------	--------	--------
Copper	1.0	1.2	1.6	1.8
Total	4.5	6.2	9.6	101.8
Index	100	138	213	2,262
Billions of gallons daily average	0.1	0.1	0.1	0.3

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	--------	200	340	350
Chemical	50	50	80	150
Pulp and paper	--------	--------	--------	18,000
Food	1,900	2,100	3,600	5,250
Aluminum	--------	--------	--------	--------
Copper	2,014	2,295	3,000	3,225
Total	3,964	4,645	7,020	26,975
Index	100	117	177	680
Water use per employee:				
Millions of gallons per year	1.1	1.3	1.4	3.8
Gallons per day	3,110	3,658	3,748	10,340

NOTE.—Details may not add to totals due to independent rounding.

TABLE 47.—*Pacific Northwest region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.3	4.9	6.2
Chemical	27.0	36.0	84.0	189.0
Pulp and paper	224.0	354.0	1,780.0	3,487.0
Food	23.0	26.0	36.0	47.0
Aluminum	11.0	15.0	93.6	245.4
Copper	2.2	2.6	4.3	5.3
Total	287.4	433.9	2,002.8	3,979.9
Index	100	151	697	1,385
Billions of gallons daily average	0.8	1.2	5.5	10.9

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	1,475	1,200	2,000	2,175
Chemical	3,000	3,000	7,000	13,000
Pulp and paper	17,000	27,000	135,000	265,000
Food	19,378	21,700	28,800	36,750
Aluminum	5,693	5,800	29,000	60,000
Copper	1,450	1,650	2,700	3,000
Total	47,996	60,350	204,500	379,925
Index	100	126	426	792
Water use per employee:				
Millions of gallons per year	6.0	7.2	9.8	10.5
Gallons per day	16,405	19,699	26,833	28,699

NOTE.—Details may not add to totals due to independent rounding.

TABLE 48.—*Great Basin region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	11.3	12.9	25.3	29.0
Chemical	4.0	5.0	12.0	27.0
Pulp and paper	0.5	1.0	2.0	44.0
Food	2.0	2.0	4.0	6.0
Aluminum	--------	--------	--------	--------
Copper	4.3	5.1	7.1	7.3
Total	22.1	26.0	50.4	113.3
Index	100	118	228	513
Billions of gallons daily average	0.1	0.1	0.1	0.3

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	9,637	8,900	13,600	13,200
Chemical	1,000	2,000	3,000	7,000
Pulp and paper	--------	--------	--------	9,000
Food	2,448	2,800	4,680	6,600
Aluminum	--------	--------	--------	--------
Copper	2,100	2,400	2,500	2,600
Total	15,185	16,100	23,780	38,400
Index	100	106	157	253
Water use per employee:				
Millions of gallons per year	1.5	1.6	2.1	3.0
Gallons per day	3,986	4,425	5,805	8,085

NOTE.—Details may not add to totals due to independent rounding.

TABLE 49.—*Central Pacific region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	0.2	0.2	10.5	15.5
Chemical	33.0	44.0	117.5	247.0
Pulp and paper	13.0	14.0	27.0	115.0
Food	34.0	44.0	78.0	107.0
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	80.2	102.2	222.5	484.5
Index	100	127	277	604
Billions of gallons daily average	0.2	0.3	0.6	1.3

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	4,077	3,600	7,500	9,300
Chemical	6,000	7,000	13,000	28,000
Pulp and paper	3,000	3,000	8,000	34,000
Food	38,982	50,400	85,500	116,550
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	52,059	64,000	114,000	187,850
Index	100	123	219	361
Water use per employee:				
Millions of gallons per year	1.5	1.6	2.0	2.6
Gallons per day	4,222	4,375	5,348	7,066

NOTE.—Details may not add to totals due to independent rounding.

TABLE 50.—*South Pacific region water intake and employment based on BDSA median projections*

A. WATER INTAKE

[Billions of gallons per year]

Industry	Years			
	1954	1959	1980	2000
Iron and steel	2.6	4.5	13.3	19.2
Chemical	10.0	13.0	31.0	71.0
Pulp and paper	4.0	6.0	16.0	66.0
Food	13.0	17.0	28.0	38.0
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	29.6	40.5	88.3	194.2
Index	100	137	298	656
Billions of gallons daily average	0.1	0.1	0.2	0.5

B. NUMBER OF EMPLOYEES

Industry	1954	1959	1980	2000
Iron and steel	8,229	11,500	22,800	27,800
Chemical	5,000	6,000	11,000	23,000
Pulp and paper	2,000	3,000	5,000	19,000
Food	21,272	27,300	43,200	59,000
Aluminum	--------	--------	--------	--------
Copper	--------	--------	--------	--------
Total	36,501	47,800	82,000	128,800
Index	100	131	225	353
Water use per employee:				
Millions of gallons per year	0.8	0.8	1.1	1.5
Gallons per day	2,222	2,321	2,951	4,132

NOTE.—Details may not add to totals due to independent rounding.

APPENDIX C. FUTURE WATER REQUIREMENTS FOR THE IRON AND STEEL INDUSTRY

INTRODUCTION

The iron and steel industry is one of the largest users of water among all manufacturing industries. In 1954, out of a total usage of 11,757 billion gallons by establishments whose water intake was 20 million gallons or more, blast furnaces, steelworks, and rolling mills (SIC Codes 3311 and 3312) accounted for 2,812 billion gallons, or 23.9 percent of the total. If there is added to this figure the usage by related industries—electrometallurgical, iron and steel foundries, forgings, and nonintegrated steel mills—the sum comes to 3,146 billion gallons, 26.7 percent of the total for all manufacturing industries.

For the purposes of this report only water usage by blast furnaces, steelworks, and rolling mills, which makes up 89.4 percent of the total for the iron and steel industry, is considered. In general the national growth of the related industries may be expected to follow rather closely that of the basic iron and steel producing industry, although, the geographical alinement of those industries will probably follow less closely the regional growth of the basic industry, due to different technological influences, market shifts, etc.

Water is an indispensable material for the iron and steel industry, with a number of uses: as a cooling agent; as a cleansing agent; as a solvent; as a catalyst; as a conveying medium for the transport of materials and for the disposal of waste; as a diluent or dispensive medium; in the production and distribution of heat and power; and for drinking, bathing, and fire protection. About 83 percent of the total is used for low-rate cooling purposes.

Measured in terms of water intake per net ton of ingots produced, the national average in 1954 was 31,842 gallons. This includes water used for all the purposes described above and not merely that used in the production of ingots as such. This figure varies considerably from one water-use region to another, depending principally upon the degree of integration, the type of iron and steel mill operation carried on in each region and the rate of recirculation of water. The amount per ton ranges from 41,589 gallons in the Western Great Lakes region down to only 350 gallons in the Central Pacific and Pacific Northwest, where there are no blast furnaces, which require large quantities of water for cooling.

For 1959 it was assumed that the average intake per ton of ingots produced would remain the same as in 1954, region by region. A steel production estimate of 110 million tons of ingots for 1959 is assumed, neglecting lost production during the steel strike. On this basis water intake by the iron and steel industry in 1959 is estimated at 3.5 billion gallons, an increase of 24.7 percent over 1954, approximately the same rate of increase as for steel output.

For the industry as a whole the proportion of brackish (salt) water in the total intake is 4.3 percent. The bulk of the intake of this water occurs in the Chesapeake Bay region, which accounts for 83 percent of the total. Industrial waste water is also used to a considerable extent by the iron and steel industry. In the Chesapeake Bay region, again, industrial waste water intake is estimated at about one-fourth of the total.

As a general rule 80 percent of the industrial water used in the steel plant is recirculated, although water used in chemical processes and to quench coke is not recirculated. According to the 1954 Census of Manufactures, the amount of water required if no water was recirculated or reused would be 3,600 billion gallons, as against the actual intake of 2,812 billion gallons. The degree of recirculation varies from plant to plant and region to region, depending largely upon the availability of water.

LOCATION OF PLANTS

The basic iron and steel industry is at present located in 18 of the 22 water use regions. About 71 percent of the total capacity is contained within three regions, as follows: 36 percent in the Ohio River region, 19 percent in the western Great Lakes region, and 16 percent in the eastern Great Lakes region. Since water is indispensable to the industry, the availability of water for its operations has been a factor in the location of iron and steel plants. The feasibility of using brackish water in large quantities has not been a deterrent to location on the coast, aside from the other advantages of water as a means of transportation of raw materials and finished products.

ELECTRIC POWER GENERATION AT PLANTS

The steel industry as a whole generates in its own plants approximately 40 percent of its electric power requirements, purchasing the remaining 60 percent from public utilities. Integrated plants with coke ovens and blast furnaces find it advantageous to use the byproduct gases from the operation of those plants for the generation of power rather than letting them go to waste. Supplemental power is provided either by generation from purchased fuels or directly from public utilities. The semi-integrated and nonintegrated mills, without coke ovens and blast furnaces must rely entirely upon generation from purchased fuels or upon public utilities. The extent to which either of the last two sources is used depends largely upon the relative costs of purchased fuels and purchased power.

EMPLOYMENT AND WATER USE PER EMPLOYEE

The number of employees in the iron and steel industry in 1954 was approximately 519,000. That year was one of comparatively low production per employee, with the BLS index of output per man-hour at 127.5 (1940=100), as compared with 132.2 in 1953 and 146.3 in 1955. The calculated ingot production per worker in 1954 was 170.26. In the first 6 months of 1959 this figure was 212.59, and on the basis of this rate of output the number of employees required to produce 110 million tons in 1959 was estimated at approximately 517,000.

Water use per employee for the industry was 5.4 million gallons in 1954 and 6.8 million gallons in 1959. As in the case of gallons per ton of ingots produced, water use per employee varied by regions, ranging in 1954 from 9,280 in the Western Great Lakes region to as little as 49 in the Central Pacific region.

FUTURE REQUIREMENTS BASED ON RFF ESTIMATES

1. *Production*

The median production indexes for the iron and steel industry, as supplied by Resources for the Future, call for the output of 248 million tons of steel ingots in 1980 and 500 million tons in the year 2000. The regional distribution of this tonnage, made by the Business and Defense Services Administration, is based upon the following assumptions: A growing dependence upon imported ores, resulting in relative increases in the coastal regions and in the Great Lakes area, served by the St. Lawrence Seaway; relative industrial growth in the south and on the west coast; and a significant relative decline in the Ohio River region. These geographical shifts are expected to take place gradually, with about half of the shift taking effect by 1980.

Employment estimates by BDSA for 1980 and 2000 in relation to the above RFF projection are based on an increase in production per employee, starting at a rate of 1.5 percent per year compounded and tapering off, by 2000, to 1.35 percent per year. This declining rate of increase is the result of an assumed drop of 10 percent in the length of workweek.

2. *Water intake and usage*

Several factors are expected to reduce water intake per ton of ingots produced. Although the adoption of direct reduction processes for iron production is not expected to account for more than one-third of increased iron output by 2000, the lower water needs for those processes than is required for blast furnaces—3,000 gallons per ton of steel in direct reduction versus 10,000 gallons in blast furnaces—would result in some lowering of water needs. Also, with lower water needs in the oxygen converter than in the open hearth either with or without oxygen added, some reduction in water needs would result in the expected widespread adoption of the oxygen converter as a steel-melting furnace. In addition some increase in recirculation of water may be expected. Finally, with less coke oven and blast-furnace gas available for electric power generation because of direct reduction processes, some shift toward purchased power may be expected, with a drop in water usage for that purpose by the iron and steel industry. As a result of all these factors it is estimated that water intake per ton of ingots produced will decrease by 10 percent from now until 1980 and an additional 10 percent from 1980 to 2000. Aside from the above considerations, intraregional changes in water use are expected to occur with the construction of iron-producing furnaces in the Central Pacific and Pacific Northwest region where they do not now exist.

Total water intake in 1980 is estimated by BDSA, based on the RFF projections, at 7,124 billion gallons and in 2000 at 12,826 billion gallons. These figures represent increases of 153 and 356 percent, respectively, over the 1954 total. Water intake per employee in 1980 is estimated at 8.2 million gallons and in 2000 at 9.7 million gallons, as compared with 5.4 million gallons in 1954.

The low and high projection of RFF would call for approximately the following quantities of water in 1980 and 2000, as compared with the RFF median figures used in this report; BDSA estimates are shown for further comparison.

Estimated water intake

[Billions of gallons]

	1980	2000
Low	4,400	5,900
Median	7,124	12,826
High	12,000	30,000
BDSA	6,837	8,210

FUTURE REQUIREMENTS BASED ON BDSA ESTIMATES

1. *Explanation of BDSA estimates*

BDSA estimates of steel production in 1980 are based on an annual growth rate of slightly under 3 percent per year (2⅞ percent) compounded, with 1955, when production was at its peak, as the base year. For the years 1980 to 2000 the estimated growth is 2¾ percent. The historical growth of the industry has been approximately 3 percent. The somewhat lower rates of growth used in this estimate take into account such factors as a growing use of other materials and an increase in the use of lighter, stronger steels.

2. *Production*

Based on the growth rates described above steel ingot output in 1980 is estimated at 238 million net tons, and that in 2000 at 320 million tons. The regional distribution of production and the employment estimates were made in the same way as was done in connection with the RFF estimates.

3. *Water intake and usage*

Total water intake in 1980 is estimated at 6,837 billion gallons and for 2000 at 8,210 billion gallons. The basic assumption as to water intake and usage, including that in electric power generation, are the same as those used in regard to the RFF estimates.

COMMENTS ON RFF AND BDSA ESTIMATES

The RFF estimates of steel production in 1980 and 2000 are believed to be too high, especially for the year 2000. The growth rate indicated up to 1980 is 3 percent compounded annually, the same as the historical growth rate. For reasons mentioned above, it is felt that the actual growth rate in this period will be somewhat lower. For 1980 to 2000 the RFF estimate indicates a growth rate of 3½ percent per year. As against this increasing growth rate the BDSA estimate calls for a somewhat lower rate from 1980 to 2000 than in the period up to 1980, in view of a greater expected use of other materials and lighter steels. Per capita production figures for each of the two estimates are as shown in the following table. These figures compare with the peak of 1,416 pounds reached in 1955. The population estimates by RFF and BDSA, used in these per capita calculations, differ only slightly from each other.

Per capita steel production

[Pounds of ingots]

	RFF estimates	BDSA estimates
1980	2,024	1,919
2000	3,021	1,910

METROPOLITAN AREAS

Total steel production data for 1954 and estimates for 1959, 1980, and 2000 are included for selected metropolitan areas, both on the basis of the RFF projections and those of BDSA. The increases for each metropolitan area were estimated at the same rate as the increases for the region in which the area is located. By coincidence typical of this industry, each of the establishments in these metropolitan areas had a water intake of 20 million gallons or more in 1954.

CONCLUSION

Water requirements (intake) by the iron and steel industry will show substantial increases in 1980 and 2000 over current needs. Based on the BDSA estimates the increase in 1980 will be 143 percent over that in 1954 and by 2000 there will be a further rise of 20 percent. The extent to which these increased needs will dictate the location of the industry will of course depend upon the availability of water in each region and the other demands by industry, including agriculture, and the general public. Because of the increasing dependence of the steel industry upon imported iron ore, it is expected that the future growth of the industry will be relatively large close to tidewater, both in the coastal regions and on the Great Lakes. The impact on the water supply will therefore be proportionately less in the river basin regions, particularly in the Ohio River region.

Certain technological changes which are still only in experimental stages may develop importantly enough to have significant effects on water usage. One of these is the direct reduction of iron ore, which is discussed in the text above. Another development significant for the future would be the use of nuclear energy for heating and power generation. A third change would be continuous casting, which would reduce or eliminate the rolling of semifinished forms of steel, thus cutting down on the use of water.

National summary of water use, iron and steel industry group

[Tables based on RFF]

Item	Years			
	1954[1]	1959[2, 3]	1980[4]	2000[4]
Index of industrial production	108	135	303	613
Total water intake, billions of gallons per year	2,812	3,500	7,123.7	12,826.5
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	88,312	110,000	248,000	500,000
Water intake per unit of production, gallons per ton	31,842	31,818	28,724	25,653
Number of employees	518,690	517,400	872,300	1,335,100
Water use per employee, thousands of gallons	5,421	6,765	8,170	9,724

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Estimated levels without strike.
[4] Based on median projection supplied by Resources for the Future, Inc.

Regional estimate of water use, iron and steel industry group

NEW ENGLAND REGION

Item	Years			
	1954[1]	1959[2, 3]	1980[4]	2000[4]
Index of industrial production	100	40	92	183
Total water intake, billions of gallons per year	1.3	0.5	1.1	1.9
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	327	132	300	600
Water intake per unit of production, gallons per ton	4,000	4,000	3,600	3,240
Number of employees	2,927	950	1,600	2,500
Water use per employee, thousands of gallons	444	526	675	760

DELAWARE AND HUDSON RIVER REGION

Item	1954[1]	1959[2, 3]	1980[4]	2000[4]
Index of industrial production	100	129	320	702
Total water intake, billions of gallons per year	196	253	566	1,120
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	5,623	7,271	17,980	39,600
Water intake per unit of production, gallons per ton	34,857	34,857	31,500	28,350
Number of employees	41,218	43,100	80,000	134,000
Water use per employee, thousands of gallons	4,755	5,870	7,075	8,358
Production in specified metropolitan areas:				
Albany-Schenectady-Troy, thousands of net tons	57	60	148	325
Philadelphia, do	2,838	3,688	9,110	20,001

See footnotes at end of table, p. 40.

Regional estimate of water use, iron and steel industry group—Continued

Item	Years			
	1954[1]	1959[2,3]	1980[4]	2000[4]
EASTERN GREAT LAKES REGION				
Index of industrial production	100	133	328	720
Total water intake billions of gallons per year	486	646	1,449	2,862
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	13,263	17,633	43,525	95,500
Water intake per unit of production gallons per ton	36,643	36,643	33,300	29,970
Number of employees	67,433	73,200	134,000	240,000
Water use per employee thousands of gallons	7,207	8,825	10,813	11,925
Production in specified metropolitan areas, in units: Detroit thousands of net tons	4,232	5,917	14,606	32,047
CHESAPEAKE BAY REGION				
Index of industrial production	100	120	296	649
Total water intake billions of gallons per year	153	184	411	810
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	6,704	8,041	19,840	43,500
Water intake per unit of production gallons per ton	22,822	22,822	20,700	18,630
Number of employees	37,714	30,100	68,000	113,000
Water use per employee thousands of gallons	4,057	6,113	6,044	7,168
WESTERN GREAT LAKES REGION				
Index of industrial production	100	117	286	620
Total water intake billions of gallons per year	738	866	1,917	3,742
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	17,745	20,823	50,715	110,000
Water intake per unit of production gallons per ton	41,589	41,589	37,800	34,020
Number of employees	79,524	75,200	138,000	228,000
Water use per employee thousands of gallons	9,280	11,516	13,891	16,412
Production in specified metropolitan areas: Chicago thousands of net tons	5,156	6,742	16,420	35,615
OHIO RIVER REGION				
Index of industrial production	100	126	236	380
Total water intake billions of gallons per year	1,034	1,302	2,213	3,209
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	31,584	39,776	74,645	120,050
Water intake per unit of production gallons per ton	32,738	32,738	29,700	26,730
Number of employees	212,630	217,550	305,000	373,000
Water use per employee thousands of gallons	4,863	5,985	7,269	8,603
Production in specified metropolitan areas: Cincinnati thousands of net tons	390	469	880	1,415
TENNESSEE RIVER REGION				
Index of industrial production	100	100	227	454
Total water intake billions of gallons per year	0.2	0.2	0.4	0.7
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	33	33	75	150
Water intake per unit of production gallons per ton	6,000	6,000	5,400	4,860
Number of employees	489	400	700	1,000
Water use per employee thousands of gallons	408	500	579	729
SOUTHEAST REGION				
Index of industrial production	100	120	336	812
Total water intake billions of gallons per year	62	74	190	413
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	3,693	4,422	12,400	30,000
Water intake per unit of production gallons per ton	16,788	16,788	15,300	13,770
Number of employees	21,870	21,000	45,000	82,000
Water use per employee thousands of gallons	2,835	3,524	4,222	5,037
Production in specified metropolitan areas: Birmingham thousands of net tons	2,843	3,113	8,729	21,119
UPPER MISSISSIPPI RIVER REGION				
Index of industrial production	100	127	275	509
Total water intake billions of gallons per year	74	94	185	308
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,965	2,486	5,405	10,000
Water intake per unit of production gallons per ton	37,659	37,659	34,200	30,780
Number of employees	10,304	10,500	17,000	24,000
Water use per employee thousands of gallons	7,182	8,952	10,882	12,833
Production in specified metropolitan areas: St. Louis thousands of net tons	1,140	1,520	3,305	6,115

See footnotes at end of table, p. 40.

Regional estimate of water use, iron and steel industry group—**Continued**

LOWER MISSOURI REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	104	215	304
Total water intake. billions of gallons per year	10	10.4	19.6	32.4
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	507	528	1,090	2,000
Water intake per unit of production gallons per ton	19,724	19,724	18,000	16,200
Number of employees	2,113	1,800	2,800	3,900
Water use per employee thousands of gallons	4,732	5,778	7,000	8,308
Production in specified metropolitan areas: Kansas City thousands of net tons	507	528	1,090	2,000

LOWER ARKANSAS-RED RIVERS REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	140	285	513
Total water intake. billions of gallons per year	7	10	17.5	28.4
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	487	682	1,390	2,500
Water intake per unit of production gallons per ton	14,374	14,374	12,600	11,340
Number of employees	3,261	3,700	5,700	7,700
Water use per employee thousands of gallons	2,146	2,703	3,070	3,688

UPPER ARKANSAS-RED RIVERS REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	111	238	452
Total water intake. billions of gallons per year	15	17	31.3	53.5
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,218	1,333	2,900	5,500
Water intake per unit of production gallons per ton	12,315	12,315	10,800	9,720
Number of employees	9,711	8,700	14,000	20,000
Water use per employee thousands of gallons	1,545	1,954	2,236	2,675

WESTERN GULF REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	118	334	810
Total water intake. billions of gallons per year	21.1	25	62.4	136
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	988	1,166	3,300	8,000
Water intake per unit of production gallons per ton	21,407	21,441	18,900	17,010
Number of employees	6,078	5,800	12,000	23,000
Water use per employee thousands of gallons	3,496	4,328	5,200	5,913
Production in specified metropolitan areas:				
Houston thousands of net tons	893	1,000	2,830	6,860
Fort Worth do	29	33	93	225

COLORADO RIVER REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	...	100	227	454
Total water intake billions of gallons per year	...	0.04	0.09	0.16
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	...	44	100	200
Water intake per unit of production gallons per ton	...	1,000	900	810
Number of employees	...	200	400	600
Water use per employee thousands of gallons	...	200	225	270

PACIFIC NORTHWEST REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	101	234	499
Total water intake billions of gallons per year	0.2	0.2	5.1	9.7
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	401	407	940	2,000
Water intake per unit of production gallons per ton	600	600	5,400	4,860
Number of employees	1,475	1,200	2,100	3,400
Water use per employee thousands of gallons	169	208	2,429	2,853
Production in specified metropolitan areas: Portland thousands of net tons	88	90	208	443

GREAT BASIN REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	114	243	464
Total water intake billions of gallons per year	11.3	12.9	26.4	45.4
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,508	1,716	3,670	7,000
Water intake per unit of production gallons per ton	7,500	7,500	7,200	6,480
Number of employees	9,637	8,900	14,000	21,000
Water use per employee thousands of gallons	1,173	1,449	1,886	2,162

See footnotes at end of table, p. 40.

Regional estimate of water use, iron and steel industry group—Continued

CENTRAL PACIFIC REGION

Item	Years			
	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of industrial production	100	109	315	773
Total water intake, billions of gallons per year	0.2	0.2	11.0	24.3
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	647	704	2,035	5,000
Water intake per unit of production, gallons per ton	350	350	5,400	4,860
Number of employees	4,077	3,600	8,000	15,000
Water use per employee, thousands of gallons	49	56	1,375	1,620
Production in specified metropolitan areas: San Francisco, thousands of net tons	647	704	2,035	5,000

SOUTH PACIFIC REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of industrial production	100	172	475	1,143
Total water intake, billions of gallons per year	2.6	4.5	13.8	30
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,619	2,783	7,690	18,500
Water intake per unit of production, gallons per ton	1,600	1,600	1,800	1,620
Number of employees	8,229	11,600	24,000	43,000
Water use per employee, thousands of gallons	316	391	575	698
Production in specified metropolitan areas: Los Angeles, thousands of net tons	517	597	1,650	3,969

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Estimated levels without strike.
[4] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated water intake, iron and steel industry

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	1.3	0.5	1.1	1.9
Delaware and Hudson	196.0	253.0	566.0	1,120.0
Eastern Great Lakes and St. Lawrence	486.0	646.0	1,449.0	2,862.0
Chesapeake Bay	153.0	184.0	411.0	810.0
Western Great Lakes	738.0	866.0	1,917.0	3,742.0
Ohio	1,034.0	1,302.0	2,217.0	3,209.0
Cumberland				
Tennessee	.2	.2	.4	.7
Southeast	62.0	74.0	190.0	413.0
Upper Mississippi	74.0	94.0	185.0	308.0
Lower Mississippi				
Upper Missouri				
Lower Missouri	10.0	10.4	19.6	32.4
Eastern Arkansas-White-Red	7.6	10.0	17.5	28.4
Western Arkansas-White-Red	15.0	17.0	31.3	53.5
Western gulf	21.1	25.0	62.4	136.0
Rio Grande				
Colorado				.2
Pacific Northwest	.2	.3	5.1	9.7
Great Basin	11.3	12.9	26.4	45.4
Central Pacific	.2	.2	11.0	24.3
South Pacific	2.6	4.5	13.8	30.0
Total	2,811.9	3,500.0	7,123.6	12,826.5

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated number of employees, iron and steel industry

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	2,927	950	1,600	2,500
Delaware and Hudson	41,218	43,100	80,000	134,000
Eastern Great Lakes and St. Lawrence	67,433	73,200	134,000	240,000
Chesapeake Bay	37,714	30,100	68,000	113,000
Western Great Lakes	79,524	75,200	138,000	228,000
Ohio	212,630	217,550	305,000	373,000
Cumberland				
Tennessee	489	400	700	1,000
Southeast	21,870	21,000	45,000	82,000
Upper Mississippi	10,304	10,500	17,000	24,000
Lower Mississippi				
Upper Missouri				
Lower Missouri	2,113	1,800	2,800	3,900
Eastern Arkansas-White-Red	3,261	3,700	5,700	7,700
Western Arkansas-White-Red	9,711	8,700	14,000	20,000
Western gulf	6,078	5,800	12,000	23,000
Rio Grande				
Colorado		200	400	600
Pacific Northwest	1,475	1,200	2,100	3,400
Creat Basin	9,637	8,900	14,000	21,000
Gentral Pacific	4,077	3,600	8,000	15,000
South Pacific	8,229	11,500	24,000	43,000
Total	518,690	517,400	872,300	1,335,100

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

National summary of water use, iron and steel industry group

[Tables based on BDSA]

Item	Years			
	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of industrial production	108	135	291	392
Total water intake ... billions of gallons per year	2,812	3,500	6,837	8,209.8
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	38,312	110,000	238,000	320,000
Water intake per unit of production ... gallons per ton of ingots	31,842	31,818	28,727	25,655
Number of employees	518,690	517,400	836,720	843,975
Water use per employee ... thousands of gallons	5,421	6,765	8,171	9,727

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958–60 adjustment.
[3] Estimated levels without strike.
[4] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional estimates of water use, iron and steel industry group

Item	Years			
	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
NEW ENGLAND REGION				
Index of industrial production	100	40	87	118
Total water intake ... billions of gallons per year	1.3	0.5	1	1.2
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	327	132	285	385
Water intake per unit of production ... gallons per ton of ingots	4,000	4,000	3,600	3,240
Number of employees	2,927	950	1,550	1,600
Water use per employee ... thousands of gallons	444	526	645	750
DELAWARE AND HUDSON RIVER REGION				
Index of industrial production	100	129	307	450
Total water intake ... billions of gallons per year	196	253	544	717
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	5,623	7,271	17,255	25,280
Water intake per unit of production ... gallons per ton	34,857	34,857	31,500	28,350
Number of employees	41,218	43,100	76,700	85,500
Water use per employee ... thousands of gallons	4,755	5,870	7,093	8,386
Production in specified metropolitan areas:				
Albany-Schnectady-Troy ... thousands of net tons	57	60	142	208
Philadelphia ... do	2,838	3,688	8,752	12,823
EASTERN GREAT LAKES REGION				
Index of industrial production	100	133	315	461
Total water intake ... billions of gallons per year	486	646	1,391	1,832
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	13,263	17,633	41,770	61,120
Water intake per unit of production ... gallons per ton	36,643	36,643	33,300	29,970
Number of employees	67,433	73,200	128,800	143,500
Water use per employee ... thousands of gallons	7,207	8,825	10,800	12,767
Production in specified metropolitan areas: Detroit ... thousands of net tons	4,232	5,917	14,017	20,510
CHESAPEAKE BAY REGION				
Index of industrial production	100	120	284	377
Total water intake ... billions of gallons per year	153	184	394	519
Production (weight, units, or dollars added in production in 1959 constant dollars thousands of net tons of steel ingots	6,704	8,041	19,040	27,840
Water intake per unit of production ... gallons per ton	22,822	22,822	20,700	18,630
Number of employees	37,714	30,100	65,000	72,300
Water use per employee ... thousands of gallons	4,057	6,113	6,062	7,178
WESTERN GREAT LAKES REGION				
Index of industrial production	100	117	274	397
Total water intake ... billions of gallons per year	738	866	1,840	2,395
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	17,745	20,823	48,670	70,400
Water intake per unit of production ... gallons per ton	41,589	41,589	37,800	34,020
Number of employees	79,524	75,200	132,400	145,700
Water use per employee ... thousands of gallons	9,280	11,516	13,897	16,438
Production in specified metropolitan areas: Chicago ... thousands of net tons	5,156	6,742	15,758	22,794

See footnotes at end of table, p 43.

Regional estimate of water use, iron and steel industry group—Continued

OHIO RIVER REGION

Item	Years 1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	126	227	243
Total water intake, billions of gallons per year	1,031	1,302	2,128	2,054
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	31,584	39,776	71,640	76,830
Water intake per unit of production, gallons per ton	32,738	32,738	29,700	26,730
Number of employees	212,630	217,550	292,800	239,000
Water use per employee, thousands of gallons	4,863	5,985	7,268	8,594
Production in specified metropolitan areas: Cincinnati, thousands of net tons	390	469	845	906

TENNESSEE REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	100	212	288
Total water intake, billions of gallons per year	0.2	0.2	0.4	0.5
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	33	33	70	95
Water intake per unit of production, gallons per ton	6,006	6,000	5,400	4,860
Number of employees	489	400	630	650
Water use per employee, thousands of gallons	408	500	603	708

SOUTHEAST REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	120	322	520
Total water intake, billions of gallons per year	62	74	182	264
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	3,693	4,422	11,900	19,200
Water intake per unit of production, gallons per ton	16,788	16,788	15,300	13,770
Number of employees	21,870	21,000	42,800	52,500
Water use per employee, thousands of gallons	2,835	3,524	4,252	5,029
Production in specified metropolitan areas: Birmingham, thousands of net tons	2,843	3,524	4,252	5,029

UPPER MISSISSIPPI RIVER REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	127	264	326
Total water intake, billions of gallons per year	[illegible]	94	177	197
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,965	2,486	5,190	6,400
Water intake per unit of production, gallons per ton	37,659	37,659	34,200	30,780
Number of employees	10,304	10,500	16,500	15,500
Water use per employee, thousands of gallons	7,182	8,952	10,727	12,710
Production in specified metropolitan areas: St. Louis, thousands of net tons	1,140	1,520	3,173	3,913

LOWER MISSOURI RIVER REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	104	206	252
Total water intake, billions of gallons per year	10	10.4	18.8	20.7
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	507	528	1,045	1,280
Water intake per unit of production, gallons per ton	19,724	19,724	18,000	16,200
Number of employees	2,113	1,800	2,600	2,500
Water use per employee, thousands of gallons	4,732	5,778	7,231	8,280
Production in specified metropolitan areas: Kansas City, thousands of net tons	507	528	1,045	1,280

LOWER ARKANSAS-RED RIVERS REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	140	274	329
Total water intake, billions of gallons per year	7	10	16.8	18.1
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	487	682	1,335	1,600
Water intake per unit of production, gallons per ton	14,374	14,374	12,600	11,340
Number of employees	3,261	3,700	5,400	4,900
Water use per employee, thousands of gallons	2,146	2,703	3,111	3,694

UPPER ARKANSAS-RED RIVERS REGION

Item	1954 [1]	1959 [2 3]	1980 [4]	2000 [4]
Index of industrial production	100	111	229	289
Total water intake, billions of gallons per year	15	17	30.1	34.2
Production (weight, units, or dollars added in production in 1959 constant dollars) thousands of net tons of steel ingots	1,218	1,353	2,785	3,520
Water intake per unit of production, gallons per ton	12,315	12,315	10,800	9,720
Number of employees	9,711	8,700	13,500	13,000
Water use per employee, thousands of gallons	1,545	1,954	2,230	2,631

See footnotes at end of table, p. 43.

Regional estimate of water use, iron and steel industry group—Continued

Item	Years			
	1954 [1]	1959 [2,3]	1980 [4]	2000 [4]
WESTERN GULF REGION				
Index of industrial production	100	118	320	518
Total water intake, billions of gallons per year	21.1	25	59.8	87.1
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	988	1,166	3,165	5,120
Water intake per unit of production, gallons per ton	21,407	21,441	18,900	17,010
Number of employees	6,078	5,800	11,800	14,500
Water use per employee, thousands of gallons	3,496	4,328	5,068	6,007
Production in specified metropolitan areas:				
Houston, thousands of net tons	863	1,000	2,714	4,390
Fort Worth, do	29	33	90	146
COLORADO RIVER REGION				
Index of industrial production	....	[illegible]	216	295
Total water intake, billions of gallons per year	....	0.04	0.85	1.05
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	....	44	95	130
Water intake per unit of production, gallons per ton	....	1,000	900	810
Number of employees	....	200	340	350
Water use per employee, thousands of gallons	....	200	250	300
PACIFIC NORTHWEST REGION				
Index of industrial production	100	101	226	319
Total water intake, billions of gallons per year	0.2	0.2	4.9	6.2
Production (weights, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	401	407	905	1,280
Water intake per unit of production, gallons per ton	600	600	5,400	4,860
Number of employees	1,475	1,200	2,000	2,175
Water use per employee, thousands of gallons	169	208	2,450	2,850
Production in specified metropolitan areas: Portland, thousands of net tons	88	90	200	283
GREAT BASIN REGION				
Index of industrial production	100	114	233	297
Total water intake, billions of gallons per year	11.3	12.9	25.3	29
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	1,508	1,716	3,520	4,480
Water intake per unit of production, gallons per ton	7,500	7,500	7,200	6,480
Number of employees	9,637	8,900	13,600	13,200
Water use per employee, thousands of gallons	1,173	1,449	1,860	2,197
CENTRAL PACIFIC REGION				
Index of industrial production	100	109	301	495
Total water intake, billions of gallons per year	0.2	0.2	10.5	15.5
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	647	704	1,950	3,200
Water intake per unit of production, gallons per ton	350	350	5,400	4,860
Number of employees	4,077	3,600	7,500	9,300
Water use per employee, thousands of gallons	49	56	1,400	1,667
Production in specified metropolitan areas: San Francisco, thousands of net tons	647	704	1,950	3,200
SOUTH PACIFIC REGION				
Index of industrial production	100	172	456	731
Total water intake, billions of gallons per year	2.6	4.5	13.3	19.2
Production (weight, units, or dollars added in production in 1959 constant dollars), thousands of net tons of steel ingots	1,619	2,783	7,380	11,840
Water intake per unit of production, gallons per ton	1,600	1,600	1,800	1,620
Number of employees	8,229	11,500	22,800	27,800
Water use per employee, thousands of gallons	316	391	583	691
Production in specified metropolitan areas: Los Angeles, thousands of net tons	517	597	1,583	2,540

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.

[2] Estimate based on 1958-60 adjustment.

[3] Estimated levels without strike.

[4] Based on projection of the FRB index of all industrial production adopted by BDSA

Regional distribution of estimated water intake, iron and steel industry

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	1.3	0.5	1.0	1.2
Delaware and Hudson	196.0	253.0	544.0	717.0
Eastern Great Lakes and St. Lawrence	486.0	646.0	1,391.0	1,832.0
Chesapeake Bay	153.0	184.0	394.0	519.0
Western Great Lakes	738.0	866.0	1,840.0	2,395.0
Ohio	1,034.0	1,302.0	2,128.0	2,054.0
Cumberland	--------	--------	--------	--------
Tennessee	.2	.2	.4	.5
Southeast	62.0	74.0	182.0	264.0
Upper Mississippi	74.0	94.0	177.0	197.0
Lower Mississippi	--------	--------	--------	--------
Upper Missouri	--------	--------	--------	--------
Lower Missouri	10.0	10.4	18.8	20.7
Eastern Arkansas-White-Red	7.0	10.0	16.8	18.1
Western Arkansas-White-Red	15.1	17.0	30.1	34.2
Western gulf	21.1	25.1	59.8	87.1
Rio Grande	--------	--------	--------	--------
Colorado	--------	--------	--------	.1
Pacific Northwest	.2	.3	4.9	6.2
Great Basin	11.3	12.9	25.3	29.0
Central Pacific	.2	.2	10.5	15.5
South Pacific	2.6	4.5	13.3	19.2
Total	2,811.9	3,500.0	6,836.9	8,209.8

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional distribution of estimated number of employees, iron and steel industry

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	2,927	950	1,550	1,600
Delaware and Hudson	41,218	43,100	76,700	85,500
Eastern Great Lakes and St. Lawrence	67,433	73,200	128,800	143,500
Chesapeake Bay	37,714	30,100	65,000	72,300
Western Great Lakes	79,524	75,200	132,400	145,700
Ohio	212,630	217,550	292,800	239,000
Cumberland	--------	--------	--------	--------
Tennessee	489	400	630	650
Southeast	21,870	21,000	42,800	52,500
Upper Mississippi	10,304	10,500	16,500	15,500
Lower Mississippi	--------	--------	--------	--------
Upper Missouri	--------	--------	--------	--------
Lower Missouri	2,113	1,800	2,600	2,500
Eastern Arkansas-White-Red	3,261	3,700	5,400	4,900
Western Arkansas-White-Red	9,711	8,700	13,500	13,000
Western gulf	6,078	5,800	11,800	14,500
Rio Grande	--------	--------	--------	--------
Colorado	--------	200	340	350
Pacific Northwest	1,475	1,200	2,000	2,175
Great Basin	9,637	8,900	13,600	13,200
Central Pacific	4,077	3,600	7,500	9,300
South Pacific	8,229	11,500	22,800	27,800
Total	518,690	517,400	836,720	843,975

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

APPENDIX D. FUTURE WATER REQUIREMENTS FOR THE CHEMICALS AND ALLIED PRODUCTS INDUSTRY

INTRODUCTION

For establishments in the chemicals and allied products industry using 20 million gallons or more, the water intake was 2,380 billion gallons in 1954 and an estimated 3,210 billion gallons in 1959. Utilizing Resources For the Future (RFF) data, the water-intake requirements are placed at 10,800 billion gallons in 1980 and at 29,700 billions in the year 2000. However, using indexes developed by Business and Defense Services Administration, these requirements amount to 8,040 billion gallons in 1980 and 19,300 billion gallons in 2000.

The chemicals and allied products industry is one of the largest consumers of water, accounting for about 23.4 percent of the water intake for all industrial uses in 1954. About 10 percent of the establishments in the chemical and allied products industry use 20 million gallons or more of water annually and account for more than 95 percent of the water intake of the chemical and allied products industry.

According to the 1954 Census of Manufactures covering establishments having an intake of 20 million gallons or more of water annually, the chemicals and allied products industry took 2,380 billion gallons. This usage may be classified into 3 broad types; (1) cooling and air-conditioning, 83 percent; (2) processing, 10 percent; and (3) boiler feed, sanitary services and miscellaneous, 7 percent.

Although the chemical industry requires water for power and heat exchange uses somewhat of the same magnitude as large industries, such as primary metals and petroleum, the chemical industry also has the large additional requirements in chemical processing as a reaction media, for washing large amounts of materials as in the rayon and cellophane plants, and particularly as an effluent diluent. These requirements are not broken down separately, and the water requirement which provides the ultimate disposal, such as various streams and the like, is not even considered in this report.

The distribution of water usage as related to production varies widely between the 31 industries comprising the major group 28 (SIC Manual 1957), the variation being some fiftyfold. The water intake per unit of production or employee is therefore a function of the character of the particular industry rather than that of the major group. Furthermore, the locations of the production establishments which reported in the 1954 census were not influenced by the water availability problem nearly as much as such sites will probably be during the periods of the projections. Therefore, any detailed attempt to extrapolate the 1954 base for water consumption by production unit or employe would necessitate an analysis of the 31 component industries by each region. Obviously such an array of data is not available.

For many years the chemicals and allied products industry has been emphasizing the conservation of water by retreatment and various means, and regards the availability of water as an important consideration in locating new plants.

In 1954 approximately 67 percent of the users of water (using 20 million gallons or more annually) recirculated or otherwise reused the water in the interest of conservation. If no water were recirculated or reused, total water required would have amounted to 4,088 billion gallons while actual water intake amounted to 2,380 billion gallons showing recirculation of 1,708 billion gallons. The latter quantity approximates 72 percent of the water intake. While this may indicate that some further progress in conservation of water through recirculation may be effected, it is doubtful that the high cost usually involved in installing cooling, corrosion inhibiting and chemically reconditioning equipment for used water would be economically justified except in a few cases. Accordingly it is assumed that the ratio of reused water to total water intake will not increase materially.

In 1954 the chemicals and allied products industry used 515 billion gallons of brackish water or 32 percent of 1,622 billion gallons of brackish water consumed by industries. In 1954, the use of brackish water in the chemical industry amounted to approximately 22 percent of its total water intake. The Western Gulf region accounted for 63 percent of the brackish water and the Delaware and Hudson region for 18 percent. Some brackish water is used as a raw material source, for instance in the production of magnesium and bromine, and the remainder for cooling and in some cases for sanitary services. The increasing cost of nonbrackish water may be expected to make use of brackish water economically interesting, particularly in view of increasing knowledge of water treatment and methods of combating corrosion and fouling of heat-exchangers caused by the use of brackish water; however, due to the cost involved in overcoming corrosion and fouling of piping and equipment, not much relative increase in the use of brackish water for this purpose is expected. Thus it is assumed that the relationship of brackish water used to total water intake will remain close to that of 1954.

LOCATION OF PLANTS OR MILLS

Until recently the greatest concentration of chemical plants had been in the northeast quadrant of the United States. The trend now, however, is a shift toward the gulf region and particularly to the western gulf area. Although this migration of the industry is due to many factors it is quite largely due to the fact that more than 50 percent of the raw materials for chemical manufacturing are now produced from oil wells. It appears that this shift will probably continue.

FUTURE WATER REQUIREMENTS

All estimates shown in this study were made by means of projections from the 1954 census data as the primary benchmark. These data are to be found in Bulletin MC 209 "Industrial Water Use," Bureau of the Census, and in revisions made during the preparation of this study.

(*a*) *Based on Estimates of Resources for the Future, Inc. (RFF)*

Estimates for 1959 are the same as those using BDSA indexes as explained under BDSA estimates; estimates for 1980 and 2000 are based primarily on the indexes of industrial production for major group 28 as supplied by the Resources for the Future, Inc.

The methods for estimating 1980 and 2000 total water intake, production value added and number of employees for national, regional, and metropolitan areas are the same as those for BDSA estimate except that the chemical production indexes used were the ones supplied by the Resources for the Future, Inc.

National.—Using RFF chemical production indexes, BDSA estimates: water intake of 10,800 billion gallons in 1980, and 29,700 billion in 2000; total production value added $34,900 million in 1980 and $99,700 million in 2000; total number of employees 998,000 in 1980 and 2,230,000 in 2000; water intake per unit of production, 309 million gallons in 1980 and 298 million in 2000; and water used per employee 10.8 million gallons in 1980 and 13.3 million in 2000.

Regions.—In relation to the water intake growth of the total United States, the expected water intake growth of the individual regions varies considerably, for instance from 180 percent of the national growth for the Western Gulf region to 50 percent for the New England region. Considering some of the regions using large quantities of water, the water intake of the Western Gulf region amounted to 471 billion gallons in 1954 and is estimated at 3,150 billion in 1980 and 10,800 billion in 2000; that of the Ohio region at 495 billion in 1954, 1,860 billion in 1980 and 4,310 billion in 2000; the Eastern Great Lakes, 352 billion in 1954, 1,320 billion in 1980, and 3,060 billion in 2000; the Delaware and Hudson region 237 billion in 1954, 864 billion in 1980, and 1,920 billion in 2000; and the Southeast region 102 billion in 1954, 596 billion in 1980, and 1,920 billion in 2000.

Likewise, in relation to the production value added growth of the United States, the expected production value added growths of the various regions varied widely, from more than twice the national growth to only 59 percent of the national. Considering some of the regions with large production value added, the production value added to the Delaware and Hudson region rose from $1,470 million in 1954 to an estimated $6,605 million for 1980 and $16,400 million in 2000; that of the Ohio region from $943 million in 1954 to $4,401 million in 1980 and $11,400 million in 2000; the Southeast region from $369 million in 1954 to $2,735 million in 1980 and $9,570 million in 2000; the Western Great Lakes region, $635 million in 1954 to $2,962 million in 1980 and $7,640 million in 2000; and the Eastern Great Lakes region from $610 million in 1954 to $2,847 million in 1980 to $7,340 million in 2000.

Metropolitan.—The production value added growths of the various metropolitan areas varied even more widely than those of the regions. For instance the Houston metropolitan area showed the greatest growth; from $203 million in 1954 to an estimated $2,215 million in 1980 and $8,814 million in 2000, and the Boston metropolitan area the least growth; from $114 million in 1954 to $243 million in 1980 and $347 million in 2000. Considering some of the metropolitan areas with large production value added, the production value added of the New York metropolitan area rose from $1,428 million in 1954 to $5,274 million in 1980 and $11,905 million in 2000; Philadelphia metropolitan area from $367 million in 1954 to $1,681 in 1980 and $4,643 million in 2000; Los Angeles metropolitan area from $218 million in 1954 to $1,214 million in 1980 and $3,807 million in 2000; Chicago metropolitan area from $531 million in 1954 to $1,752 million in 1980 and $3,407 million in 2000; and St. Louis from $237 million in 1954 to $1,059 in 1980 and $2,861 million in 2000.

(*b*) *Based on BDSA Estimates*

National.—The estimates for 1959, 1980, and 2000 shown in the summary for the United States are based primarily on the progression extrapolation of the FRB index of industrial production for major group 28 developed by this division from an inspection graphic projection of the line trend exhibited by the FRB index for group 28 since 1947.

Total water intake (for the establishments using 20 million gallons or more annually) estimates were projected upon estimated FRB index of industrial production group 28. No allowances were made for possible increases in use of recirculated water because expected increase would be small.

The production value added estimates (for establishments using 20 million gallons or more) were based primarily upon the FRB production indexes for group 28 and adjusted by the relationship of the FRB index group 28 to production value added group 28 (all establishments) during 1947–57 to compensate for the steeper increase in value added.

Likewise the number of employees projections (for establishments using 20 million gallons or more) were based primarily upon the FRB indexes group 28 to the number of employees group 28 (all establishments) during 1947–57 to compensate for the slower increase in the number of employees. This indicates a greater output per employee.

Water intake per unit of production and per employee was obtained by dividing respectively the water intake by production value added and by the number of employees.

For establishments using 20 million or more gallons annually U.S. total water intake was 2,380 billion gallons in 1954, and estimated at 3,210 billion in 1959, at 8,040 billion in 1980, and 19,300 billion in 2000. Total production value added amounted to $6,650 million in 1954 and is estimated at $8,980 million in 1959, at $25,600 million in 1980, and $63,400 million in 2000. Total number of employees was 459,000 in 1954 and is estimated at 505,000 in 1959, at 818,000 in 1980, and 1,549,000 in 2000. Water intake per unit of production went from 358 million in 1958 and 1959 to 314 million in 1980 and 304 million in 2000; water use per employee went from 5.18 million gallons in 1954, to 6.36 million in 1959, to 9.3 million in 1980, and 12.5 million in 2000.

Regions.—The 1947–57 growth pattern of production value added of group 28 (all establishments) for the 9 census regions, from data published in the Survey of Manufactures, Bureau of the Census, formed the basis for estimating the growth of production value added in the 22 water regions; this was accomplished by placing each water region into the most logical census region. The growth factor of each region was applied to the percent of 1954 total production value added for establishments using 20 million gallons or more annually for the region and projected; these projections were applied to the U.S. totals for the respective years.

The same method (but applying the growth in number of employees) was used for estimating the number of employees.

However, for the total water intake for the regions, growth patterns of water intake by the 9 census regions were not available and reliance was made on the production value added for the 9 census regions adjusted to the 22 water regions and further adjusted downward to compensate for the faster rise in production value added than in FRB index. The growth factor for each region was applied to the percent of 1954 total water intake for establishments using 20 million gallons or more annually; these projections were applied to U.S. totals for the respective years.

In addition for three areas—Upper Rio Grande and Pecos, Colorado, and Great Basin—where the 1954 data for water intake and number of employees were not available, the small 1954 residue (the difference between the U.S. total and the sum of the other areas) was distributed on the basis of knowledge of the chemical industry in these three areas for 1954 and projected by the methods given above.

In relation to the water intake growth of the total United States, the expected water intake growths of the individual regions vary considerably, for instance, from 180 percent of the national growth for the Western Gulf region to 50 percent for the New England region. Considering some of the regions using large quantities of water, the water intake of the Western Gulf region rose from 471 billion gallons in 1954 to an estimated 2,340 billion in 1980 and 7,010 billion in 2000; that of the Ohio region from 495 billion gallons in 1954 to 1,390 billion in 1980 and 2,800 billion in 2000; the Eastern Great Lakes from 352 billion in 1954 to 987 billion in 1980 and 1,990 billion in 2000; the Delaware and Hudson from 237 billion in 1954 to 643 billion in 1980 and 1,250 billion in 2000; and the Southeast region from 102 billion in 1954 to 4[illegible] billion in 1980, and 1,250 in 2000.

Likewise in relation to the production value added growth of the total United States, the expected production value added growths of the individual regions varied widely, from more than twice the national growth to only 59 percent of the national. Considering some of the regions with large production value added, the production value added of the Delaware and Hudson region amounted to $1,470 million in 1954, and is estimated at $4,840 million in 1980 and $10,400 million in 2000; that of the Ohio region $943 million in 1954, $3,230 million in 1980 and $7,220 million in 2000; the Southeast region $369 million in 1954, $2,000 million in 1980 and $6,090 million in 2000; the Western Great Lakes region $635 million in 1954, $2,170 million in 1980 and $4,860 million in 2000; and the Eastern Great Lakes region, $610 million in 1954, $2,090 million in 1980 and $4,670 million in 2000.

Metropolitan.—The 1947–57 growth pattern of production value added of group 28 (all establishments, not those with water intake of 20 million gallons or more) for the metropolitan areas formed the basis for estimated 1959, 1980, and 2000 production value added for these areas. The 1947–57 growth factor for each area was expressed as a percentage of the national growth of major group 28 for all establishments. This growth factor for each area was applied to the percent of the 1954 total production value added (all establishments) and projected. These projections were applied to the U.S. totals for the respective years. Knowledge of the industry dictated only a very few minor adjustments.

As would be expected, the production value added growths of the various metropolitan areas varied even more widely than those of the regions. For instance, the Houston metropolitan area showed the greatest growth from $203 million in 1954 to an estimated $1,875 million in 1980 and $6,720 million in 2000 and the Boston metropolitan area the smallest growth from $114 million in 1954 to $205 million in 1980 and $270 million in 2000. Considering some of the metropolitan areas with large production value added, the production value added of the New York metropolitan area rose from $1,428 million in 1954 to $4,462 million in 1980 and $9,077 million in 2000; Philadelphia metropolitan area from $367 million in 1954 to $1,423 in 1980 and $3,540 in 2000; Los Angeles metropolitan area from $218 million in 1954 to $1,027 million in 1980 and $2,902 million in 2000; Chicago metropolitan area from $531 million in 1954 to $1,482 million in 1980 and $2,597 million in 2000; and St. Louis metropolitan area from $237 million in 1954 to $896 million in 1980 and $2,181 in 2000.

National summary of water use, chemicals and allied products industry group

[Tables based on RFF]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	148	200	673	1,850
Total water intake [4] billions of gallons per year	2,380	3,210	10,800	29,700
Production [4] millions of dollars added in production in 1959 constant dollars	6,650	8,980	34,900	99,700
Water intake per unit of production millions of gallons	358	357	309	298
Number of employees [4] thousands	459	505	998	2,230
Water use per employee millions of gallons	5.18	6.36	10.6	13.3

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.

[2] Estimate based on 1958–60 adjustment.

[3] Based on median projection supplied by Resources for the Future, Inc.

[4] Establishments using 20,000,000 gallons or more annually.

Regional estimate of water use, chemical and allied products industry group

NEW ENGLAND REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	127	329	634
Total water intake [4] billions of gallons per year	41	52	135	260
Production [4] millions of dollars added in production in 1959 constant dollars	195	252	786	1,720
Water intake per unit of production millions of gallons	210	206	172	151
Number of employees [4] thousands	14	15	28	59
Water use per employee millions of gallons	2.93	3.47	4.82	4.41
Production in specified metropolitan areas:				
Boston millions of dollars added	114	139	243	347
Hartford do	11	16	57	158

DELAWARE AND HUDSON REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	365	810
Total water intake [4] billions of gallons per year	[illegible]	308	864	1,920
Production [4] millions of dollars added in production in 1959 constant dollars	1,470	1,920	6,605	16,400
Water intake per unit of production millions of gallons	161	160	131	117
Number of employees [4] thousands	99	108	198	410
Water use per employee millions of gallons	2.39	2.85	4.36	4.68
Production in specified metropolitan areas:				
New York millions of dollars added	1,428	1,858	5,274	11,905
Philadelphia do	367	[illegible]	1,681	4,643
Albany, Schenectady, Troy do	47	59	128	170

See footnotes at end of table, p. 50.

Regional estimate of water use, chemical and allied products industry group—Continued

Item	Years			
	1954 [1]	1959 [2, 3]	1980 [4]	2000 [4]
EASTERN GREAT LAKES REGION				
Index of chemical production, group 28	100	130	375	870
Total water intake [4] billions of gallons per year	352	459	1,320	3,060
Production [4] millions of dollars added in production in 1959 constant dollars	610	806	2,847	7,340
Water intake per unit of production millions of gallons	577	569	464	417
Number of employees [4] thousands	47	52	103	231
Water use per employee millions of gallons	7.49	8.83	12.8	13.2
Production in specified metropolitan areas: Detroit millions of dollars added	225	295	865	2,037
CHESAPEAKE BAY REGION				
Index of chemical production, group 28	100	135	442	1,190
Total water intake [4] billions of gallons per year	144	194	636	1,710
Production [4] millions of dollars added in production in 1959 constant dollars	970	505	2,047	6,070
Water intake per unit of production millions of gallons	389	384	311	282
Number of employees [4] thousands	30	32	62	136
Water use per employee millions of gallons	4.80	6.06	10.3	12.6
Production in specified metropolitan areas:				
Washington millions of dollars added	NA	NA	NA	NA
Richmond do	NA	NA	NA	NA
WESTERN GREAT LAKES REGION				
Index of chemical production, group 28	100	130	377	870
Total water intake [4] billions of gallons per year	167	218	630	1,450
Production [4] millions of dollars added in production in 1959 constant dollars	635	839	2,962	7,640
Water intake per unit of production millions of gallons	263	260	213	190
Number of employees [4] thousands	42	46	92	205
Water use per employee millions of gallons	3.98	4.74	6.85	7.07
Production in specified metropolitan areas:				
Chicago millions of dollars added	531	678	1,752	3,407
Lansing do	NA	NA	NA	NA
OHIO RIVER REGION				
Index of chemical production, group 28	100	130	376	870
Total water intake [4] billions of gallons per year	495	646	1,860	4,310
Production [4] millions of dollars added in production in 1959 constant dollars	943	1,250	4,401	11,400
Water intake per unit of production millions of gallons	525	517	423	378
Number of employees [4] thousands	67	74	146	326
Water use per employee millions of gallons	7.39	8.73	12.7	13.2
Production in specified metropolitan areas:				
Cincinnati millions of dollars added	198	264	847	2,207
Indianapolis do	110	145	459	1,176
CUMBERLAND REGION				
Index of chemical production, group 28	100	129	379	860
Total water intake [4] billions of gallons per year	14	18	53	120
Production [4] millions of dollars added in production in 1959 constant dollars	(5)	(5)	(5)	(5)
Water intake per unit of production millions of gallons	NA	NA	NA	NA
Number of employees [4] thousands	8	9	18	40
Water use per employee millions of gallons	1.75	2.00	2.94	3.00
Production in specified metropolitan areas: Nashville millions of dollars added	NA	NA	NA	NA
TENNESSEE REGION				
Index of chemical production, group 28	100	132	395	960
Total water intake [4] billions of gallons per year	152	200	600	1,460
Production [4] millions of dollars added in production in 1959 constant dollars	235	314	1,156	3,130
Water intake per unit of production millions of gallons	647	637	519	466
Number of employees [4] thousands	24	26	46	93
Water use per employee millions of gallons	6.33	7.69	13.0	15.7
Production in specified metropolitan areas: Chattanooga millions of dollars added	75	98	282	655
SOUTHEAST REGION				
Index of chemical production, group 28	100	142	584	1,880
Total water intake [4] billions of gallons per year	102	145	596	1,920
Production [4] millions of dollars added in production in 1959 constant dollars	369	537	2,735	9,570
Water intake per unit of production millions of gallons	276	270	218	201
Number of employees [4] thousands	26	29	63	150
Water use per employee millions of gallons	3.92	5.00	9.46	12.8
Production in specified metropolitan areas:				
Birmingham millions of dollars added	12	16	40	61
Columbia, S.C do	NA	NA	NA	NA

See footnotes at end of table, p. 50.

Regional estimate of water use, chemical and allied products industry group—Continued

UPPER MISSISSIPPI REGION

Item	Years			
	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	132	382	870
Total water intake [4] billions of gallons per year	38	50	145	330
Production [4] millions of dollars added in production in 1959 constant dollars	359	474	1,676	4,330
Water intake per unit of production millions of gallons	106	105	87	76
Number of employees [4] thousands	27	30	59	132
Water use per employee millions of gallons	1.41	1.67	2.46	2.5
Production in specified metropolitan areas:				
Cedar Rapids millions of dollars added	NA	NA	NA	NA
St. Louis do	237	319	1,059	2,861

LOWER MISSISSIPPI REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	146	666	2,290
Total water intake [4] billions of gallons per year	41	60	273	940
Production [4] millions of dollars added in production in 1959 constant dollars	185	280	1,582	5,850
Water intake per unit of production millions of gallons	222	214	173	161
Number of employees [4] thousands	13	14	31	76
Water use per employee millions of gallons	3.15	4.29	8.81	12.4
Production in specified metropolitan areas: New Orleans millions of dollars added	15	18	35	52

UPPER MISSOURI RIVER REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	130	420	1,100
Total water intake [4] billions of gallons per year	10	13	42	110
Production [4] millions of dollars added in production in 1959 constant dollars	88	119	464	1,320
Water intake per unit of production millions of gallons	114	100	91	83
Number of employees [4] thousands	8	9	20	50
Water use per employee millions of gallons	1.25	1.44	2.10	2.20
Production in specified metropolitan areas:				
Denver millions of dollars added	31	41	124	303
Sioux City do	NA	NA	NA	NA

LOWER MISSOURI RIVER REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	100	300	1,000
Total water intake [4] billions of gallons per year	1	1	3	9
Production [4] millions of dollars added in production in 1959 constant dollars	14	19	66	160
Water intake per unit of production millions of gallons	71	53	49	56
Number of employees [4] thousands	1	1	2	5
Water use per employee millions of gallons	1	1	1.5	2
Production in specified metropolitan areas: Kansas City millions of dollars added	104	132	340	655

LOWER ARKANSAS, WHITE, AND RED RIVERS REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	131	393	930
Total water intake [4] billions of gallons per year	29	38	114	270
Production [4] millions of dollars added in production in 1959 constant dollars	105	138	471	1,180
Water intake per unit of production millions of gallons	276	275	242	229
Number of employees [4] thousands	7	8	16	36
Water use per employee millions of gallons	4.14	4.75	7.13	7.5
Production in specified metropolitan areas: Little Rock millions of dollars added	NA	NA	NA	NA

UPPER ARKANSAS, WHITE, AND RED RIVERS REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	150	675	2,250
Total water intake [4] billions of gallons per year	8	12	54	180
Production [4] millions of dollars added in production in 1959 constant dollars	49	75	419	1,560
Water intake per unit of production millions of gallons	163	160	129	115
Number of employees [4] thousands	3	3	6	16
Water use per employee millions of gallons	2.67	4	9	11.3
Production in specified metropolitan areas:				
Oklahoma City millions of dollars added	NA	NA	NA	NA
Amarillo do	NA	NA	NA	NA

WESTERN GULF REGION

Item	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
Index of chemical production, group 28	100	147	669	2,290
Total water intake [4] billions of gallons per year	471	693	3,150	10,800
Production [4] millions of dollars added in production in 1959 constant dollars	(6)	(6)	(6)	(6)
Water intake per unit of production millions of gallons	NA	NA	NA	NA
Number of employees [4] thousands	27	31	67	161
Water use per employee millions of gallons	17.4	22.4	47	67.1
Production in specified metropolitan areas:				
Houston millions of dollars added	203	348	2,215	8,814
Dallas do	35	46	137	327
Fort Worth do	NA	NA	NA	NA
San Antonio do	NA	NA	NA	NA

See footnotes at end of table, p. 50.

Regional estimate of water use, chemical and allied products industry group—Continued

Item	Years			
	1954 [1]	1959 [2] [3]	1980 [4]	2000 [4]
UPPER RIO GRANDE AND PECOS REGION				
Index of chemical production, group 28	100	100	300	1,000
Total water intake [4] ... billions of gallons per year	[7] 1	1	3	10
Production [4] ... millions of dollars added in production in 1959 constant dollars	(6)	(6)	(6)	(6)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands	[7] 0.05	0.05	0.1	0.22
Water use per employee ... millions of gallons	20	20	30	40.4
Production in specified metropolitan areas, in units: Albuquerque ... millions of dollars added	NA	NA	NA	NA
COLORADO REGION				
Index of chemical production, group 28	100	100	300	900
Total water intake [4] ... billions of gallons per year	[7] 1	1	3	9
Production [4] ... millions of dollars added in production in 1959 constant dollars	(6)	(6)	(6)	(6)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands	[7] 0.05	0.05	0.1	0.22
Water use per employee ... millions of gallons	20	20	30	40.4
Production in specified metropolitan areas:				
Phoenix ... millions of dollars added	NA	NA	NA	NA
Grand Junction ... do	NA	NA	NA	NA
PACIFIC NORTHWEST REGION				
Index of chemical production, group 28	100	133	415	1,070
Total water intake [4] ... billions of gallons per year	27	36	112	290
Production [4] ... millions of dollars added in production in 1959 constant dollars	43	58	227	650
Water intake per unit of production ... millions of gallons	625	621	493	446
Number of employees [4] ... thousands	3	3	8	19
Water use per employee ... millions of gallons	9	12	14	15.3
Production in specified metropolitan areas:				
Portland ... millions of dollars added	NA	NA	NA	NA
Spokane ... do	NA	NA	NA	NA
GREAT BASIN REGION				
Index of chemical production, group 28	100	125	400	1,050
Total water intake [4] ... billions of gallons per year	[7] 4	5	16	42
Production [4] ... millions of dollars added in production in 1959 constant dollars	(6)	(6)	(6)	(6)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands	[7] 1	2	4	9
Water use per employee ... millions of gallons	2.64	3.00	4.22	4.48
Production in specified metropolitan areas: Salt Lake City ... millions of dollars added	NA	NA	NA	NA
CENTRAL PACIFIC REGION				
Index of chemical production, group 28	100	133	436	1,150
Total water intake [4] ... billions of gallons per year	33	44	144	380
Production [4] ... millions of dollars added in production in 1959 constant dollars	111	151	604	1,760
Water intake per unit of production ... millions of gallons	297	291	238	216
Number of employees [4] ... thousands	6	7	16	40
Water use per employee ... millions of gallons	5.5	6.29	9	9.5
Production in specified metropolitan areas: San Francisco ... millions of dollars added	156	196	432	606
SOUTH PACIFIC REGION				
Index of chemical production, group 28	100	130	420	1,100
Total water intake [4] ... billions of gallons per year	10	13	42	110
Production [4] ... millions of dollars added in production in 1959 constant dollars	98	132	513	1,460
Water intake per unit of production ... millions of gallons	102	98	82	75
Number of employees [4] ... thousands	5	6	13	35
Water use per employee ... millions of gallons	2	2.17	3.23	3.33
Production in specified metropolitan areas: Los Angeles ... millions of dollars added	215	308	1,214	3,807

---

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projectionsu pplied by Resources for the Future, Inc.
[4] Establishments using 20,000,000 gallons or more annually.
[5] Disclosure.
[6] Not available, possible disclosure.
[7] Estimated.

Regional distribution of estimated water intake, chemicals industry group

Region	Water intake in billions of gallons per year			
	1954[1]	1959[2]	1980[3]	2000[3]
New England	41	52	135	260
Delaware and Hudson	237	308	864	1,920
Eastern Great Lakes and St. Lawrence	352	459	1,320	3,060
Chesapeake Bay	144	194	636	1,710
Western Great Lakes	167	218	630	1,450
Ohio	495	646	1,860	4,310
Cumberland	14	18	53	120
Tennessee	152	200	600	1,460
Southeast	102	145	596	1,920
Upper Mississippi	38	50	145	330
Lower Mississippi	41	60	273	940
Upper Missouri	10	13	42	110
Lower Missouri	1	1	3	9
Eastern Arkansas-White-Red	29	38	114	270
Western Arkansas-White-Red	8	12	54	180
Western gulf	471	603	3,150	10,800
Rio Grande	[4] 1	1	3	10
Colorado	[4] 1	1	3	9
Pacific Northwest	27	36	112	290
Great Basin	[4] 4	5	16	42
Central Pacific	33	44	144	380
South Pacific	10	13	42	110
Total	2,380	3,210	10,800	29,700

[1] From MC 209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958–60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.
[4] Estimated.

Regional distribution of estimated number of employees, chemicals industry group

Region	Number of employees			
	1954[1]	1959[2]	1980[3]	2000[3]
New England	14,000	15,000	28,000	59,000
Delaware and Hudson	99,000	108,000	196,000	410,000
Eastern Great Lakes and St. Lawrence	47,000	52,000	103,000	231,000
Chesapeake Bay	30,000	32,000	62,000	136,000
Western Great Lakes	42,000	46,000	92,000	205,000
Ohio	67,000	74,000	146,000	326,000
Cumberland	8,000	9,000	18,000	40,000
Tennessee	24,000	26,000	46,000	93,000
Southeast	26,000	29,000	63,000	150,000
Upper Mississippi	27,000	30,000	59,000	132,000
Lower Mississippi	13,000	14,000	31,000	76,000
Upper Missouri	8,000	9,000	20,000	50,000
Lower Missouri	1,000	1,000	2,000	5,000
Eastern Arkansas-White-Red	7,000	8,000	16,000	36,000
Western Arkansas-White-Red	3,000	3,000	6,000	16,000
Western gulf	27,000	31,000	67,000	161,000
Rio Grande	[4] 50	50	100	220
Colorado	[4] 50	50	100	220
Pacific Northwest	3,000	3,000	8,000	19,000
Great Basin	[4] 1,000	2,000	4,000	9,000
Central Pacific	6,000	7,000	16,000	40,000
South Pacific	5,000	6,000	13,000	33,000
Total	459,000	505,000	998,000	2,230,000

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958–60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.
[4] Estimated.

National summary of water use, chemical and allied products industry group

[Tables based on BDSA]

Item	Years			
	1954[1]	1959[2]	1980[3]	2000[3]
Index of chemical production, group 28	148	200	500	1,200
Total water intake[4] billions of gallons per year	2,380	3,210	8,040	19,300
Production[4] millions of dollars added in production in 1959 constant dollars	6,650	8,980	25,600	63,400
Water intake per unit of production millions of gallons	358	358	314	304
Number of employees[4] thousands	459	505	818	1,549
Water use per employee millions of gallons	5.18	6.36	9.83	12.5

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958–60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] Establishments using 20,000,000 gallons or more annually.

Regional estimate of water use, chemicals and allied products industry group

NEW ENGLAND REGION

Item	Years 1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	127	244	415
Total water intake [4] ... billions of gallons per year	41	52	101	170
Production [4] ... millions of dollars added in production in 1959 constant dollars	195	252	576	1, 100
Water intake per unit of production ... millions of gallons	210	206	175	155
Number of employees [4] ... thousands	14	15	23	41
Water use per employee ... millions of gallons	2. 93	3. 47	4. 39	4. 15
Production in specified metropolitan areas:				
Boston ... millions of dollars added	114	139	205	270
Hartford ... do	11	16	49	120

DELAWARE AND HUDSON REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	271	530
Total water intake [4] ... billions of gallons per year	237	308	643	1, 250
Production [4] ... millions of dollars added in production in 1959 constant dollars	1, 470	1, 920	4, 840	10, 400
Water intake per unit of production ... millions of gallons	161	160	133	120
Number of employees [4] ... thousands	99	108	162	285
Water use per employee ... millions of gallons	2. 39	2. 85	3. 97	4. 39
Production in specified metropolitan areas:				
New York ... millions of dollars added	1, 428	1, 858	4, 462	9, 077
Philadelphia ... do	367	496	1, 423	3, 540
Albany-Schenectady-Troy ... do	47	59	108	129

EASTERN GREAT LAKES-ST. LAWRENCE REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	280	570
Total water intake [4] ... billions of gallons per year	352	459	987	1, 990
Production [4] ... millions of dollars added in production in 1959 constant dollars	610	806	2, 090	4, 670
Water intake per unit of production ... millions of gallons	577	569	472	426
Number of employees [4] ... thousands	47	52	85	161
Water use per employee ... millions of gallons	7. 49	8. 83	11. 6	12. 4
Production in specified metropolitan areas: Detroit ... millions of dollars added	225	295	732	1, 553

CHESAPEAKE BAY REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	135	329	770
Total water intake [4] ... billions of gallons per year	144	194	474	1, 110
Production [4] ... millions of dollars added in production in 1959 constant dollars	370	505	1, 500	3, 860
Water intake per unit of production ... millions of gallons	389	384	316	288
Number of employees [4] ... thousands	30	32	51	95
Water use per employee ... millions of gallons	4. 80	6. 06	9. 29	11. 7
Production in specified metropolitan areas:				
Washington ... millions of dollars added	NA	NA	NA	NA
Richmond ... do	NA	NA	NA	NA

WESTERN GREAT LAKES REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	280	570
Total water intake [4] ... billions of gallons per year	167	218	468	944
Production [4] ... millions of dollars added in production in 1959 constant dollars	635	839	2, 170	4, 860
Water intake per unit of production ... millions of gallons	263	260	216	194
Number of employees [4] ... thousands	42	46	75	142
Water use per employee ... millions of gallons	3. 98	4. 74	6. 24	6. 65
Production in specified metropolitan areas:				
Chicago ... millions of dollars added	531	678	1, 482	2, 597
Lansing ... do	NA	NA	NA	NA

OHIO REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	281	570
Total water intake [4] ... billions of gallons per year	495	646	1, 390	2, 800
Production [4] ... millions of dollars added in production in 1959 constant dollars	943	1, 250	3, 230	7, 220
Water intake per unit of production ... millions of gallons	525	517	430	388
Number of employees [4] ... thousands	67	74	119	[illegible]
Water use per employee ... millions of gallons	7. 39	8. 73	11. 7	12. 4
Production in specified metropolitan areas:				
Cincinnati ... millions of dollars added	198	264	727	1, 682
Indianapolis ... do	110	145	388	897

See footnotes at end of table, p. 55.

Regional estimate of water use, chemical and allied products industry group—Continued

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
CUMBERLAND REGION				
Index of chemical production, group 28	100	129	279	560
Total water intake [4] ……billions of gallons per year	14	18	39	79
Production [4] ……millions of dollars added in production in 1959 constant dollars	(5)	(5)	(5)	(5)
Water intake per unit of production……millions of gallons	NA	NA	NA	NA
Number of employees [4] ……thousands	8	9	15	28
Water use per employee……millions of gallons	1.75	2.00	2.60	2.82
Production in specified metropolitan area: Nashville……millions of dollars added	NA	NA	NA	NA
TENNESSEE REGION				
Index of chemical production, group 28	100	132	294	630
Total water intake [4] ……billions of gallons per year	152	200	447	951
Production [4] ……millions of dollars added in production in 1959 constant dollars	235	314	847	1,990
Water intake per unit of production……millions of gallons	647	637	528	478
Number of employees [4] ……thousands	24	26	38	65
Water use per employee……millions of gallons	6.33	7.69	11.8	14.6
Production in specificed metropolitan areas, Chattanooga……millions of dollars added	75	98	239	499
SOUTHEAST REGION				
Index of chemical production, group 28	100	142	435	1,230
Total water intake [4] ……billions of gallons per year	102	145	444	1,250
Production [4] ……millions of dollars added in production in 1959 constant dollars	369	537	2,000	6,090
Water intake per unit of production……millions of gallons	276	270	222	205
Number of employees [4] ……thousands	26	29	51	104
Water use per employee……millions of gallons	3.92	5	8.71	12
Production in specified metropolitan areas:				
Birmingham……millions of dollars added	12	16	34	46
Columbia, S.C……do	NA	NA	NA	NA
UPPER MISSISSIPPI REGION				
Index of chemical production, group 28	100	132	279	560
Total water intake [4] ……billions of gallons per year	38	50	106	214
Production [4] ……millions of dollars added in production in 1959 constant dollars	359	474	1,230	2,750
Water intake per unit of production……millions of gallons	106	105	86	78
Number of employees [4] ……thousands	27	30	48	92
Water use per employee……millions of gallons	1.41	1.67	2.21	2.33
Production in specified metropolitan areas group 28, all establishments:				
Cedar Rapids……millions of dollars added	NA	NA	NA	NA
St. Louis……do	237	319	896	2,181
LOWER MISSISSIPPI REGION				
Index of chemical production, group 28	100	146	498	1,480
Total water intake [4] ……billions of gallons per year	41	60	204	608
Production [4] ……millions of dollars added in production in 1959 constant dollars	185	280	1,160	3,720
Water intake per unit of production……millions of gallons	222	214	176	163
Number of employees [4] ……thousands	13	14	26	52
Water use per employee……millions of gallons	3.15	4.29	7.85	11.7
Production in specified metropolitan areas: New Orleans……millions of dollars added	15	18	30	42
UPPER MISSOURI RIVER REGION				
Index of chemical production, group 28	100	130	310	710
Total water intake [4] ……billions of gallons per year	10	13	31	71
Production [4] ……millions of dollars added in production in 1959 constant dollars	88	119	340	843
Water intake per unit of production……millions of gallons	114	109	91	84
Number of employees [4] ……thousands	8	9	16	35
Water use per employee……millions of gallons	1.25	1.44	1.94	2.03
Production in specified metropolitan areas:				
Denver……millions of dollars added	31	41	105	231
Sioux City……do	NA	NA	NA	NA
LOWER MISSOURI RIVER REGION				
Index of chemical production, group 28	100	100	200	600
Total water intake [4] ……billions of gallons per year	1	1	2	6
Production [4] ……millions of dollars added in production in 1959 constant dollars	14	19	49	101
Water intake per unit of production……millions of gallons	71	53	48	59
Number of employees [4] ……thousands	1	1	2	4
Water use per employee……millions of gallons	1	1	1	1.50
Production in specified metropolitan areas: Kansas City……millions of dollars added	104	132	288	499

See footnotes at end of table, p. 55.

***Regional estimate of water use, chemical and allied products industry group*—Continued**

LOWER ARKANSAS, WHITE, AND RED RIVERS REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	131	293	620
Total water intake [4] ... billions of gallons per year	29	38	85	179
Production [4] ... millions of dollars added in production in 1959 constant dollars	105	138	346	748
Water intake per unit of production ... millions of gallons	276	275	246	239
Number of employees [4] ... thousands	7	8	13	25
Water use per employee ... millions of gallons	4.14	4.75	6.54	7.16
Production in specified metropolitan areas: Little Rock ... millions of dollars added	NA	NA	NA	NA

UPPER ARKANSAS, WHITE, AND RED RIVERS REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	150	500	1,500
Total water intake [4] ... billions of gallons per year	8	12	40	120
Production [4] ... millions of dollars added in production in 1959 constant dollars	49	75	307	989
Water intake per unit of production ... millions of gallons	163	160	130	121
Number of employees [4] ... thousands	3	3	5	11
Water use per employee ... millions of gallons	2.67	4	8	10.9
Production in specified metropolitan areas:				
Oklahoma City ... millions of dollars added	NA	NA	NA	NA
Amarillo ... do	NA	NA	NA	NA

WESTERN GULF REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemicals production, group 28	100	147	497	1,490
Total water intake [4] ... billions of gallons per year	471	693	2,340	7,010
Production [4] ... millions of dollars added in production in 1959 constant dollars	(5)	(5)	(5)	(5)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands	27	31	55	112
Water use per employee ... millions of gallons	17.4	22.4	42.5	62.6
Production in specified metropolitan areas:				
Houston ... millions of dollars added	203	348	1,875	6,720
Dallas ... do	35	46	116	250
Fort Worth ... do	NA	NA	NA	NA
San Antonio ... do	NA	NA	NA	NA

UPPER RIO GRANDE AND PECOS REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	100	200	600
Total water intake [4] ... billions of gallons per year (estimated)	1	1	2	6
Production [4] ... millions of dollars added in production in 1959 constant dollars	(5)	(5)	(5)	(5)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands (estimated)	0.05	0.05	0.08	0.15
Water use per employee ... millions of gallons	20	20	24.4	38.7
Production in specified metropolitan areas: Albuquerque ... millions of dollars added	NA	NA	NA	NA

COLORADO REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	100	200	600
Total water intake [4] ... billions of gallons per year (estimated)	1	1	2	6
Production [4] ... millions of dollars added in production in 1959 constant dollars	(5)	(5)	(5)	(5)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands (estimated)	0.05	0.05	0.08	0.15
Water use per employee ... millions of gallons	20	20	24.4	38.7
Production in specified metropolitan areas:				
Phoenix ... millions of dollars added	NA	NA	NA	NA
Grand Junction ... do	NA	NA	NA	NA

PACIFIC NORTHWEST REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	133	311	700
Total water intake [4] ... billions of gallons per year	27	36	84	189
Production [4] ... millions of dollars added in production in 1959 constant dollars	43	58	166	412
Water intake per unit of production ... millions of gallons	628	621	506	459
Number of employees [4] ... thousands	3	3	7	13
Water use per employee ... millions of gallons	9	12	12	14.5
Production in specified metropolitan areas:				
Portland ... millions of dollars added	NA	NA	NA	NA
Spokane ... do	NA	NA	NA	NA

See footnotes at end of table, p. 55.

Regional estimate of water use, chemical and allied products industry group—Continued

GREAT BASIN REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemicals production, group 28	100	125	300	680
Total water intake [4] ... billions of gallons per year (estimated)	4	5	12	27
Production [4] ... millions of dollars added in production in 1959 constant dollars	(6)	(6)	(6)	(6)
Water intake per unit of production ... millions of gallons	NA	NA	NA	NA
Number of employees [4] ... thousands (estimated)	1	2	3	7
Water use per employee ... millions of gallons	2.64	3.00	3.86	4.15
Production in specified metropolitan areas: Salt Lake City ... millions of dollars added	NA	NA	NA	NA

CENTRAL PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	133	324	750
Total water intake [4] ... billions of gallons per year	33	44	107	247
Production [4] ... millions of dollars added in production in 1959 constant dollars	111	151	442	1,120
Water intake per unit of production ... millions of gallons	297	291	242	221
Number of employees [4] ... thousands	6	7	13	28
Water use per employee ... millions of gallons	5.5	6.29	8.23	8.82
Production in specified metropolitan areas: San Francisco ... millions of dollars added	156	196	366	462

SOUTH PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of chemical production, group 28	100	130	310	710
Total water intake [4] ... billions of gallons per year	10	13	31	71
Production [4] ... millions of dollars added in production in 1959 constant dollars	98	132	376	932
Water intake per unit of production ... millions of gallons	102	98	82	76
Number of employees [4] ... thousands	5	6	11	23
Water use per employee ... millions of gallons	2	2.17	2.82	3.09
Production in specified metropolitan areas: Los Angeles ... millions of dollars added	218	308	1,027	2,902

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] Establishments using 20,000,000 gallons or more.
[5] Less than 1,000.
[6] 1954 value-added data estimated, not provided in MC-209.

Regional distribution of estimated water intake, chemicals industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	41	52	101	170
Delaware and Hudson	237	308	643	1,250
Eastern Great Lakes and St. Lawrence	352	450	987	1,990
Chesapeake Bay	144	194	474	1,110
Western Great Lakes	167	218	468	944
Ohio	495	646	1,390	2,800
Cumberland	14	18	39	79
Tennessee	152	200	447	951
Southeast	102	145	444	1,250
Upper Mississippi	38	50	106	214
Lower Mississippi	41	60	204	608
Missouri, upper	10	13	31	71

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Missouri, lower	1	1	2	6
Arkansas-White-Red, eastern	29	38	85	179
Arkansas-White-Red, western	8	12	40	120
Western Gulf	471	693	2,340	7,010
Rio Grande	[4] 1	1	2	6
Colorado	[4] 1	1	2	6
Pacific Northwest	27	36	84	189
Great Basin	[4] 4	5	12	27
Central Pacific	33	44	107	247
South Pacific	10	13	31	71
Total	2,380	3,210	8,040	19,300

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] Estimated.

Regional distribution of estimated number of employees, chemicals industry group

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	14,000	15,000	23,000	41,000
Delaware and Hudson	99,000	108,000	162,000	285,000
Eastern Great Lakes and St. Lawrence	47,000	52,000	85,000	161,000
Chesapeake Bay	30,000	32,000	51,000	95,000
Western Great Lakes	42,000	46,000	75,000	142,000
Ohio	67,000	74,000	119,000	226,000
Cumberland	8,000	9,000	15,000	28,000
Tennessee	24,000	26,000	38,000	65,000
Southeast	26,000	29,000	51,000	104,000
Upper Mississippi	27,000	30,000	48,000	92,000
Lower Mississippi	13,000	14,000	26,000	52,000
Missouri, upper	8,000	9,000	16,000	35,000
Missouri, lower	1,000	1,000	2,000	4,000
Arkansas-White-Red, eastern	7,000	8,000	13,000	25,000
Arkansas-White-Red, western	3,000	3,000	5,000	11,000
Western Gulf	27,000	31,000	55,000	112,000
Rio Grande	[4] 50	50	80	150
Colorado	[4] 50	50	80	150
Pacific Northwest	3,000	3,000	7,000	13,000
Great Basin	[4] 1,000	2,000	3,000	7,000
Central Pacific	6,000	7,000	13,000	28,000
South Pacific	5,000	6,000	11,000	23,000
Total	459,000	505,000	818,000	1,549,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] Estimated.

APPENDIX E. FUTURE WATER REQUIREMENTS FOR THE PULP AND PAPER INDUSTRY

INTRODUCTION

This industry encompasses major group 26, "paper and allied products," as defined by the Bureau of the Budget in the 1957 edition of "Standard Industrial Classification Manual." This group includes 16 specific industries which may be broadly described as pulp mills, papermills, paperboard mills, building paper and building board mills, paper container and box plants, and other converted paper and paperboard products plants.

Census statistics disclose that industry group 26 is a major user of water, ranking as the third largest industrial user in the United States in both total water intake and total water use. While each of the 16 individual specific industries in group 26 requires water to some degree, primary manufacturers of pulp, paper, paperboard, building paper, and building boards are, by far, the major consumers. The water intake data shown in the census report on industrial water use, which covers manufacturers using 20 million gallons or more a year (gross intake), "other" industries included in group 26.

The 1954 water intake for this industry group according to census statistics was 1,600 billion gallons. The water intake requirements for the year 1980 based on the median RFF projections come to 6,893 billion gallons and for the year 2000 reaches 16,173 billion gallons. Utilizing projections which BDSA believes are more realistic, and which are comparable to projections of the low RFF indexes, the water intake requirements are 5,252 billion gallons for the year 1980 and 10,458 billion gallons for the year 2000.

In the primary pulp, paper, and board manufacturing industry there is a very wide variation in the quantities of water required for the major products produced, such as the several important grades of woodpulp and the several important grade groups of paper and board. This variation ranges from 10,000 gallons of water required per ton of output for ground woodpulp to as high as 90,000 gallons per ton for bleached sulphite paper.[1] In this study it was necessary to assume that the rate of growth to the year 2000 would be the same for all products in this group.

While it is known that some U.S. pulpmills located in coastal areas, particularly in the South, are using brackish water in certain stages of their pulp manufacturing process, U.S. mills have not yet resorted to the use of open sea water as a number of mills abroad have done in order to reduce their consumption of fresh water. Owing to wide fluctuations in the properties of sea water, it must, of course, be suitably treated before it can be used in a regular and continuous manner and, if it is very highly salted, the problem of corrosion of metals also arises. Despite these difficulties, however, the time may well come when, because of lack of adequate supplies of fresh water, U.S. mills will be obliged to make use of salty water to a greater degree. The technical aspects of using such water in pulp production are discussed in an article in the September 14, 1959, issue of the Paper Trade Journal, entitled "How French Firm Uses Ocean Water in Manufacture of Sulphite Pulp."

LOCATION OF MILLS

The location of plants for the manufacture of pulp, paper, and board is based primarily on the availability of commercial timberlands and commercially available fresh water.

Over recent years necessary economies in manufacturing have dictated the construction of large integrated mills of 100,000 tons to 500,000 tons annual capacity, incorporating the production of woodpulp together with principal grades of paper, paperboard, and building boards. (An average of 300,000 tons per year was used in this report.) In many instances this integration is carried farther to incorporate at the same millsite converting of the paper and board into end products, such as boxes, bags, etc. In planning locations for such new capacity expansion, the industry must locate a site where sufficient commercial timber is currently and prospectively available to meet capacity requirements, and, at the same time, be located in an area where large quantities of fresh water are available. In addition to these factors, there are other economic considerations such as proximity to markets, relative transportation costs, labor availability, and related matters.

---

[1] See table I "Water Requirements of the Pulp and Paper Industry," prepared by the U.S. Department of the Interior, 1955.

The important areas of privately owned commercial timberlands available for acquisition are comparatively limited. There are 4,500,000 (mostly farmers) of small parcels of woodlands accounting for 55 percent of total commercial timberlands in the United States. Federal, State, county, and municipal ownership accounts for 26 percent, with the bulk of public holdings being under control of the Forest Service of the U.S. Department of Agriculture. The forest products industries have medium and large holdings amounting to 12 percent, while other private medium and large holdings account for the remaining 7 percent of the total.[3] Since 1953, when these data were compiled, there have been many important timberland acquisitions by large pulp and paper companies so that it may be stated that practically all available large consolidated commercial timberland areas are already under ownership or control of the important existing forest products manufactures, especially pulp, paper, and board.

PRODUCTION

The timberland resource situation in the United States was appraised by the Forest Service of the Department of Agriculture in its publication "Timber Resources for the Future," published in 1958. By the year 2000 the industries' requirement would be 2½ to 3 times current requirements. This study indicates that sufficient commercial timber of pulpwood quality should be available to meet these needs provided intensified forestry management of timberlands is increased not only by commercial owners but particularly by the small woodlands owners in addition to full utilization of cull trees, tops, and wood waste from other forest products industries. The Forest Service has estimated potential realizable annual growth possible on commercial timberlands in the United States totaling 27.5 billion cubic feet (table 281 on p. 477 of "Timber Resources for America's Future"). In terms of standard cords of pulpwood this would yield a maximum potential annual growth in the future of approximately 370 million standard cords.

While it may be possible to grow sufficient pulpwood timber in future years to meet the Forest Service projections of pulp, paper, and board production, it appears unlikely that timber supply would be sufficient to meet the quantities indicated by the RFF projections. The RFF projected index of pulp, paper, and board production to the year 2000 points to an increase in necessary domestic production amounting to about six times more than was produced in the year 1959 compared to less than half this increase cited above.

FUTURE REQUIREMENTS BASED ON ESTIMATES OF "RESOURCES FOR THE FUTURE, INC."

1. Production

The median projections of national economic growth furnished by "Resources for the Future, Inc.," and a projection in terms of the FRB index for the pulp, paper, and paperboard manufacturing industry were employed in the computations.

Since it is known that the converted paper and board industries rely upon the primary pulp, paper, and board industries for their principal raw material, it was assumed that the level of production activity in all group 26 industries on the average is approximately the same. Thus, the RFF estimated FRB index of total pulp, paper, and board production has been assumed to be equal to the index of total pulp, paper, and board and converted products production.

For production of group 26, in terms of constant dollars, value added by manufacture as shown in the "Census of Manufactures for 1954" was utilized as a base figure. This was adjusted in terms of 1959 constant dollars on the basis of price changes through July 1959. The ratio of 1954 production (in terms of 1959 constant dollars) to the 1954 index of total pulp, paper, and board production was used to determine the production estimates for 1959, 1980, and 2000, in terms of value added by manufacture. The estimates for the indicated years were 3,832, 10,929, and 26,982 millions of dollars added, respectively.

2. Water intake and usage

The "1954 Census of Manufactures" shows the industry group 26 water intake to be 1,607 billion gallons. A ratio was developed between billions of gallons of water intake in 1954 and the FRB 1954 index of pulp, paper, and board production. This ratio was applied to the estimated index of pulp, paper, and board production for 1959, 1980, and 2000 to arrive at future water intake which amounted to 2,140 billion, 6,893 billion, and 16,173 billion gallons, respectively.

The water intake in units of production remained constant and was derived by dividing total water intake by production in terms of "value added by manufacture" (1959 constant dollars).

3. Employment

The total number of employees for industry group 26 was taken from the Bureau of the Census publication "Industrial Water Use" for the year 1954. Since the 1954 water-use survey was limited to manufacturing establishments in group 26 which consumed more than 20 million gallons of water in 1954, the number of employees shown is substantially below the total number actually employed in the industry as covered in the "1954 Census of Manufactures": 252,000 compared to 330,000.

Productivity varies widely in the 16 industries in group 26, as well as by individual products and specific grades of products. Thus, it is estimated that productivity factors in the different segments will offset one another, and the number of employees per unit of output will remain fairly constant for the industry as a whole. For this reason, the ratio of number of employees in 1954 to the index of pulp, paper, and board production was used to determine the estimate of employees for the years 1959, 1980, and 2000 amounting to 321,000, 847,000, 2,028,000 employees, respectively.

The water requirement per employee was determined by dividing total water intake by number of employees. For the years 1959, 1980, and 2000 these figures are 6,700, 8,100, and 8,000 gallons per employee.

---

[3] Data from "Timber Resources for the Future" (January 1958).

FUTURE REQUIREMENTS BASED ON BDSA ESTIMATES

In analyzing the relative potential growth trends in the production of pulp, paper, board, and products by regions in the United States, the following broad criterion was followed. It is apparent by the year 2000 the forest products industries, including pulp, paper, and board, will have to utilize all available commercial timber in terms of maximum annual timber growth.

Regions

The statistics contained in "Timber Resources for America's Future" on current timber volume and on realizable potential growth indicate that in the next 20 years (to 1980) there will be a more than average increase in pulp, paper, and board production in the West, where large stands of mature virgin timber exist. From 1980 to the year 2000 increasingly greater reliance would have to be placed by the industry on net annual growth to meet their needs. A combination of these two factors has been taken into consideration by the BDSA in making the approximations as to the sections in the United States where new mills could or would be built, and capacity increased, relative to the projected total national output of paper and board in 1980 and 2000. BDSA is of the opinion that the largest growth will occur in the Pacific Northwest.

The relative growth trends in paper and board production in the United States by census regions comparing 1957 with 1947 serve largely as a basis for recent and near-future expectations with more rapid shifts in new mill locations relative to timber supply probably taking place by the years 1970–80. As indicated above, during the period 1980 to 2000, mill locations will more likely be relative to commercial timberland areas where forestry and management practices could produce net annual increases in growing stock to meet pulpwood requirements. This is most likely to occur in the Pacific Northwest.

Metropolitan areas

Regarding the production of group 26 products in the specified metropolitan areas, it is unlikely that future production by these industry segments (primary pulp and paper) which use significant quantities of water (over 20 million gallons of water per plant per year) will be located in the metropolitan areas specified in this study. If so, these establishments will usually self-supply their water requirements. It is expected that new capacities will be located in the smaller towns and communities near commercial timberlands.

The following table lists the value added by manufacture for the major industry group 26, pulp, paper and products, in the selected metropolitan areas for 1954, 1959, 1980 and 2000. The table includes converted paper and paperboard products, thus encompassing the entire industry group.

Information is not available on total water use for the entire industry group so the projections are made on "value added in production" reflecting extensions of the 1947–57 growth trends for the specified metropolitan areas. All values shown have been converted to 1959 constant dollars.

Value added by manufacture for industry group 26, pulp, paper and products, by selected metropolitan areas, 1954, and estimated for 1959, 1980, and 2000

[Thousands of 1959 constant dollars]

Metropolitan areas	1954	1959	1980	2000
Albany-Schenectady-Troy, N.Y.	20,921	19,906	21,000	23,000
Boston, Mass.	80,385	76,484	80,000	90,000
Chattanooga, Tenn.	12,215	16,346	55,570	178,222
Chicago, Ill.	203,083	211,206	339,839	504,986
Cincinnati, Ohio	54,823	57,619	70,996	86,620
Dallas, Tex.	16,931	20,598	46,940	102,852
Detroit, Mich.	43,175	55,100	155,513	407,322
Fort Worth, Tex.	8,521	11,951	49,484	191,489
Hartford, Conn.	7,516	8,298	12,574	18,684
Houston, Tex.	26,451	71,801	200,000	1,800,000
Indianapolis, Ind.	17,078	22,854	77,693	249,175
Kansas City, Mo.	29,629	36,047	82,143	179,990
Los Angeles, Calif.	105,630	155,202	781,271	3,641,489
New York, N.Y.	426,168	470,489	712,979	1,500,000
Philadelphia, Pa.	201,486	222,441	337,086	501,015
Portland, Oreg.	82,966	105,881	294,994	782,718
San Francisco, Calif.	72,706	111,865	683,371	3,000,000
St. Louis, Mo.	60,696	73,843	168,274	368,716

Within the specified metropolitan areas, since few of the primary pulp and paper establishments are included, a high percentage of the value added in production is represented by the converting industries. These have comparatively small water requirements and accordingly usually purchase water from the public water utilities.

The areas of greatest expansion are estimated to be in Los Angeles from $155,202,000 in 1959 to $3,641,489,000 in 2000, San Francisco from $111,856,000 in 1959 to $3 billion in 2000, and Houston from $71,801,000 in 1959 to $1,800 million in 2000.

Comments on estimates based on RFF and BDSA data

The following table shows the comparative differences of production indexes between the BDSA and the median RFF analyses:

Total pulp, paper, and board	1959	1980	2000	Percent increase 2000 over 1959	Average annual percent increase (compounded)
By RFF	169	482	1,190	604	4.9
By BDSA	169	370	773	357	3.8

Total water intake requirements for the year 2000 amount to 16,173 billion gallons per year, compared to 10,458 billion gallons per year using the BDSA projections.

The RFF projection of total paper and board production for the year 2000 indicates a requirement of pulpwood of 264 million standard cords per year compared to 171 million standard cords according to BDSA requirements. Similarly, an estimate as to the number of new large pulp, paper, and board mills that would be required to produce the quantities of projected paper and board output by these two statistical projections would come to 403 for BDSA projections compared to 687 based on RFF data.

National summary of water use, pulp, paper, and products industry group 26

[Tables based on RFF]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1947–49=100)	132	169	482	1, 190
2. Total water intake ... billions of gallons per year	1, 607	2, 140	6, 893	16, 173
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	2, 993	3, 832	10, 929	36, 982
4. Water intake (line 2÷line 3) ... gallons per $1 of value added	537	558	631	599
5. Number of employees ... thousands	252	321	847	2, 028
6. Water use per employee (line 2÷line 5) ... thousands of gallons	6. 4	6. 7	8. 1	8
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958–60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional estimate of water use, pulp, paper, and products industry group 26

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
NEW ENGLAND REGION				
1. Index of industrial production (1954=100)	100	133	308	684
2. Total water intake ... billions of gallons per year	249	331	767	1, 703
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	355	472	1, 093	2, 428
4. Water intake (line 2÷line 3) ... gallons per $1 of value added	701	701	701	701
5. Number of employees ... thousands	38	51	117	260
6. Water use per employee (line 2÷line 5) ... thousands of gallons	6. 6	6. 6	6. 6	6. 6
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
DELAWARE AND HUDSON REGION				
1. Index of industrial production (1954=100)	100	110	114	103
2. Total water intake ... billions of gallons per year	93	102	106	96
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	287	316	328	295
4. Water intake (line 2÷line 3) ... gallons per $1 of value added	323	323	323	323
5. Number of employees ... thousands	26	29	30	27
6. Water use per employee (line 2÷line 5) ... thousands of gallons	3. 6	3. 6	3. 6	3. 6
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
EASTERN GREAT LAKES REGION				
1. Index of industrial production (1954=100)	100	124	230	284
2. Total water intake ... billions of gallons per year	110	137	253	313
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	190	236	437	540
4. Water intake (line 2÷line 3) ... gallons per $1 of value added	579	579	579	579
5. Number of employees ... thousands	20	25	46	57
6. Water use per employee (line 2÷line 5) ... thousands of gallons	5. 5	5. 5	5. 5	5. 5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
CHESAPEAKE BAY REGION				
1. Index of industrial production (1954=100)	100	159	517	911
2. Total water intake ... billions of gallons per year	109	174	563	994
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	148	236	765	1, 349
4. Water intake (line 2÷line 3) ... gallons per dollar of value added	736	736	736	736
5. Number of employees ... thousands	14	22	72	128
6. Water use per employee (line 2÷line 5) ... thousands of gallons	7. 8	7. 8	7. 8	7. 8
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
WESTERN GREAT LAKES REGION				
1. Index of industrial production (1954=100)	100	110	179	265
2. Total water intake ... billions of gallons per year	142	156	254	376
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	305	336	546	809
4. Water intake (line 2÷line 3) ... gallons per dollar of value added	466	466	466	466
5. Number of employees ... thousands	27	30	48	72
6. Water use per employee (line 2÷line 5) ... thousands of gallons	5. 3	5. 3	5. 3	5. 3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

See footnotes at end of table, p. 62.

Regional estimate of water use, pulp, paper, and products industry group 26—Continued

OHIO RIVER REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	110	167	413
2. Total water intake	54	60	90	223
3. Production billions of gallons per year	196	216	328	809
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	276	278	276	276
5. Number of employees gallons per dollar of value added	18	20	30	74
6. Water use per employee (line 2÷line 5) thousands	3	3	3	3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

CUMBERLAND REGION

1. Index of industrial production (1954=100)	100	660	2,180	5,400
2. Total water intake [4]	2	13	44	108
3. Production billions of gallons per year	5	33	109	270
4. Water intake [4] (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	400	400	400	400
5. Number of employees gallons per dollar of value added	(5)	2	7	16
6. Water use per employee [4] (line 2÷line 5) thousands	6.5	6.5	6.5	6.5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

TENNESSEE RIVER REGION

1. Index of industrial production (1954=100)	100	112	263	651
2. Total water intake	37	41	97	241
3. Production billions of gallons per year	83	93	218	540
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	446	446	446	446
5. Number of employees gallons per dollar of value added	7	8	18	46
6. Water use per employee (line 2÷line 5) thousands	5.3	5.3	5.3	5.3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

SOUTHEAST REGION

1. Index of industrial production (1954=100)	100	145	507	1,198
2. Total water intake	329	476	1,669	3,941
3. Production billions of gallons per year	473	685	2,399	5,666
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	696	696	696	696
5. Number of employees gallons per dollar of value added	34	49	172	407
6. Water use per employee (line 2÷line 5) thousands	9.7	9.7	9.7	9.7
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

UPPER MISSISSIPPI REGION

1. Index of industrial production (1954=100)	100	110	154	286
2. Total water intake	114	125	176	326
3. Production billions of gallons per year	283	311	437	809
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	403	403	403	403
5. Number of employees gallons per dollar of value added	22	24	34	63
6. Water use per employee (line 2÷line 5) thousands	5.2	5.2	5.2	5.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

LOWER MISSISSIPPI REGION

1. Index of industrial production (1954=100)	100	110	237	1,137
2. Total water intake	31	34	73	364
3. Production billions of gallons per year	92	101	218	1,079
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	337	337	337	337
5. Number of employees gallons per dollar of value added	6	7	14	70
6. Water use per employee (line 2÷line 5) thousands	5.2	5.2	5.2	5.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

UPPER MISSOURI RIVER REGION

1. Index of industrial production (1954=100)	0	0	0	------
2. Total water intake	0	0	0	300
3. Production billions of gallons per year	0	0	0	810
4. Water intake (line 2÷line 3) millions of dollars of value added by manufacture in 1959 constant dollars	------	------	------	370
5. Number of employees gallons per dollar of value added	0	0	0	60
6. Water use per employee (line 2÷line 5) thousands	------	------	------	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text. thousands of gallons				

See footnotes at end of table, p. 62.

Regional estimate of water use, pulp, paper, and products industry group 26—Continued

LOWER MISSOURI RIVER REGION

Item	Years			
	19[illegible]	1959 [3]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	122	404	2,000
2. Total water intake [4] .... billions of gallons per year	10	12	40	200
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	27	33	109	539
4. Water intake [4] (line 2÷line 3) .... gallons per dollar of value added	370	370	370	370
5. Number of employees .... thousands	2	2	8	40
6. Water use per employee [4] (line 2÷line 5) .... thousands of gallons	5	5	5	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

LOWER ARKANSAS-RED AND WHITE RIVERS REGION

1. Index of industrial production (1954=100)	100	110	299	739
2. Total water intake .... billions of gallons per year	56	62	168	414
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 146	161	437	1,079
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	384	384	384	384
5. Number of employees .... thousands	11	12	33	82
6. Water use per employee (line 2÷line 5) .... thousands of gallons	5.1	5.1	5.1	5.1
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

UPPER ARKANSAS-RED RIVERS REGION

1. Index of industrial production (1954=100)	0	0	0	----------
2. Total water intake .... billions of gallons per year	0	0	0	103
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	0	0	0	270
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	----------	----------	----------	384
5. Number of employees .... thousands	0	0	0	20
6. Water use per employee (line 2÷line 5) .... thousands of gallons	----------	----------	----------	51
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

WESTERN GULF REGION

1. Index of industrial production (1954=100)	100	140	454	1,125
2. Total water intake .... billions of gallons per year	29	41	132	326
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 48	67	218	540
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	605	605	605	605
5. Number of employees .... thousands	4	6	18	45
6. Water use per employee (line 2÷line 5) .... thousands of gallons	7.3	7.3	7.3	7.3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

UPPER RIO GRANDE AND PECOS RIVER REGION

1. Index of industrial production (1954=100)	0	0	0	----------
2. Total water intake .... billions of gallons per year	0	0	0	170
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	0	0	0	270
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	0	0	0	6.3
5. Number of employees .... thousands	0	0	0	21
6. Water use per employee (line 2÷line 5) .... thousands of gallons	0	0	0	8.1
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

COLORADO RIVER REGION

1. Index of industrial production (1954=100)	100	250	350	27,000
2. Total water intake [4] .... billions of gallons per year	0.5	1	2	135
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	2	5	7	540
4. Water intake [4] (line 2÷line 3) .... gallons per dollar of value added	250	250	250	250
5. Number of employees .... thousands	(5)	(5)	(5)	27
6. Water use per employee [4] (line 2÷line 5) .... thousands of gallons	5	5	5	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

PACIFIC NORTHWEST REGION

1. Index of industrial production (1954=100)	100	158	1,072	2,453
2. Total water intake .... billions of gallons per year	224	354	2,401	5,494
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	285	450	3,055	6,991
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	786	786	786	786
5. Numebr of employees .... thousands	17	27	182	417
6. Water use per employee (line 2÷line 5) .... thousands of gallons	13.2	13.2	13.2	13.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

See footnotes at end of table, p. 62.

Regional estimate of water use, pulp, paper, and products industry group 26—Continued

GREAT BASIN REGION

Item	Years			
	1954[1]	1959[2]	1980[3]	2000[3]
1. Index of industrial production (1954=100)	100	250	350	13,800
2. Total water intake[4] .... billions of gallons per year	0.5	1	2	68
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	2	5	7	270
4. Water intake[4] (line 2÷line 3) .... gallons per dollar of value added	250	250	250	250
5. Number of employees .... thousands	(5)	(5)	(5)	14
6. Water use per employee[4] (line 2÷line 5) .... thousands of gallons	(5)	(5)	(5)	(5)
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

CENTRAL PACIFIC REGION

Item	1954[1]	1959[2]	1980[3]	2000[3]
1. Index of industrial production (1954=100)	100	110	277	1,633
2. Total water intake .... billions of gallons per year	13	14	36	177
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 42	46	138	686
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	260	260	260	260
5. Number of employees .... thousands	3	3	11	52
6. Water use per employee (line 2÷line 5) .... thousands of gallons	3.4	3.4	3.4	3.4
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

SOUTH PACIFIC REGION

Item	1954[1]	1959[2]	1980[3]	2000[3]
1. Index of industrial production (1954=100)	100	125	500	1,638
2. Total water intake .... billions of gallons per year	4	6	20	101
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 24	30	80	393
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	260	260	260	260
5. Number of employees .... thousands	2	3	6	30
6. Water use per employee (line 2÷line 5) .... thousands of gallons	3.4	3.4	3.4	3.4
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.
[4] 1954 water-use data estimated, not provided in MC-209.
[5] Less than 1,000.
[6] 1954 value-added data estimated, not provided in MC-209.

Regional distribution of estimated water intake, pulp, paper, and products industry group

Region	Water intake in billions of gallons per year				Region	Water intake in billions of gallons per year			
	1954[1]	1959[2]	1980[3]	2000[3]		1954[1]	1959[2]	1980[3]	2000[3]
New England	249	331	767	1,703	Lower Missouri	10	12	40	200
Delaware and Hudson	93	102	106	96	Eastern Arkansas-White-Red	56	62	168	414
Eastern Great Lakes and St. Lawrence	110	137	253	313	Western Arkansas-White-Red	--------	--------	--------	103
Chesapeake Bay	109	174	563	994	Western Gulf	29	41	132	326
Western Great Lakes	142	156	254	376	Rio Grande	--------	--------	--------	170
Ohio	54	60	90	223	Colorado	.5	1	2	135
Cumberland	2	13	44	108	Pacific Northwest	224	354	2,401	5,494
Tennessee	37	41	97	241	Great Basin	.5	1	2	68
Southeast	329	476	1,669	3,941	Central Pacific	13	14	36	177
Upper Mississippi	114	125	176	326	South Pacific	4	6	20	101
Lower Mississippi	31	34	73	364					
Upper Missouri	--------	--------	--------	300	Total	1,607	2,140	6,893	16,173

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated number of employees, pulp, paper, and products industry group

Region	Number of employees				Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]		1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	38,000	51,000	117,000	260,000	Lower Missouri	2,000	2,000	8,000	40,000
Delaware and Hudson	26,000	29,000	30,000	27,000	Eastern Arkansas-White-Red	11,000	12,000	33,000	82,000
Eastern Great Lakes and St. Lawrence	20,000	25,000	46,000	57,000	Western Arkansas-White-Red				20,000
Chesapeake Bay	14,000	22,000	72,000	128,000	Western Gulf	4,000	6,000	18,000	45,000
Western Great Lakes	27,000	30,000	48,000	72,000	Rio Grande				21,000
Ohio	18,000	20,000	30,000	74,000	Colorado	(4)	(4)	(4)	27,000
Cumberland	(4)	2,000	7,000	16,000	Pacific Northwest	17,000	27,000	182,000	417,000
Tennessee	7,000	8,000	18,000	46,000	Great Basin	(4)	(4)	(4)	14,000
Southeast	34,000	49,000	172,000	407,000	Central Pacific	3,000	3,000	11,000	52,000
Upper Mississippi	22,000	24,000	34,000	63,000	South Pacific	2,000	3,000	6,000	30,000
Lower Mississippi	6,000	7,000	14,000	70,000					
Upper Missouri				60,000	Total	252,000	321,000	847,000	2,028,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.
[4] Less than 1,000.

National summary of water use, pulp, paper, and products industry group 26

[Tables based on BDSA]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1947-49=100)	132	169	370	773
2. Total water intake .... billions of gallons per year	1,607	2,140	5,252	10,458
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	2,993	3,832	8,390	17,527
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	537	558	626	597
5. Number of employees .... thousands	252	321	652	1,320
6. Water use per employee (line 2÷line 5) .... thousands of gallons	6.4	6.7	8.1	8

Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on BDSA projection.

Regional estimate of water use, pulp, paper, and products industry group 26

NEW ENGLAND REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	133	236	444
2. Total water intake .... billions of gallons per year	249	331	588	1,106
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	355	472	839	1,577
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	701	701	701	701
5. Number of employees .... thousands	38	51	90	169
6. Water use per employee (line 2÷line 5) .... thousands of gallons	6.6	6.6	6.6	6.6

Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.

DELAWARE AND HUDSON REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	110	114	103
2. Total water intake .... billions of gallons per year	93	102	106	96
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	287	316	328	295
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	323	323	323	323
5. Number of employees .... thousands	26	29	30	27
6. Water use per employee (line 2÷line 5) .... thousands of gallons	3.6	3.6	3.6	3.6

Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.

EASTERN GREAT LAKES REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	124	177	184
2. Total water intake .... billions of gallons per year	110	137	194	203
3. Production .... millions of dollars of value added by manufacture in 1959 constant dollars	190	236	335	351
4. Water intake (line 2÷line 3) .... gallons per dollar of value added	579	579	579	579
5. Number of employees .... thousands	20	25	35	37
6. Water use per employee (line 2÷line 5) .... thousands of gallons	5.5	5.5	5.5	5.5

Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.

See footnotes at end of table, p. 66.

Regional estimate of water use, pulp, paper, and products industry group 26—Continued

Item	Years			
	1954 [1]	1959 [2]	1980 [2]	2000 [2]
CHESAPEAKE BAY REGION				
1. Index of industrial production (1954=100)	100	159	397	592
2. Total water intake...billions of gallons per year	109	174	432	646
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	148	236	587	876
4. Water intake (line 2+line 3)...gallons per dollar of value added	736	736	736	736
5. Number of employees...thousands	14	22	55	83
6. Water use per employee (line 2+line 5)...thousands of gallons	7.8	7.8	7.8	7.8
Appropriate comments: National and regional data for 1959, 1890, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
WESTERN GREAT LAKES REGION				
1. Index of industrial production (1954=100)	100	110	137	172
2. Total water intake...billions of gallons per year	142	156	195	244
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	305	336	419	526
4. Water intake (line 2+line 3)...gallons per dollar of value added	466	466	466	466
5. Number of employees...thousands	27	30	37	47
6. Water use per employee (line 2+line 5)...thousands of gallons	5.3	5.3	5.3	5.3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
OHIO RIVER REGION				
1. Index of industrial production (1954=100)	100	110	128	268
2. Total water intake...billions of gallons per year	54	60	69	145
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	196	216	252	526
4. Water intake (line 2÷line 3)...gallons per dollar of value added	276	276	276	276
5. Number of employees...thousands	18	20	23	48
6. Water use per employee (line 2÷line 5)...thousands of gallons	3	3	3	3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
CUMBERLAND RIVER REGION				
1. Index of industrial production (1954=100)	100	660	1,674	3,508
2. Total water intake [4]...billions of gallons per year	2	13	34	70
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	5	33	84	175
4. Water intake [4] (line 2÷line 3)...gallons per dollar of value added	400	400	400	400
5. Number of employees...thousands	(5)	2	5	10
6. Water use per employee [4] (line 2+line 5)...thousands of gallons	6.5	6.5	6.5	6.5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to thelimitations and qualifications as stated in the accompanying text.				
TENNESSEE RIVER REGION				
1. Index of industrial production (1954=100)	100	112	202	423
2. Total water intake...billions of gallons per year	37	41	74	157
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	83	93	168	351
4. Water intake (line 2+line 3)...gallons per dollar of value added	446	446	446	446
5. Number of employees...thousands	7	8	14	30
6. Water use per employee (line 2+line 5)...thousands of gallons	5.3	5.3	5.3	5.3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
SOUTHEAST REGION				
1. Index of industrial production (1954=100)	100	145	389	778
2. Total water intake...billions of gallons per year	329	476	1,281	2,560
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	473	685	1,842	3,681
4. Water intake (line 2+line 3)...gallons per dollar of value added	696	696	696	696
5. Number of employees...thousands	34	49	132	264
6. Water use per employee (line 2+line 5)...thousands of gallons	9.7	9.7	9.7	9.7
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
UPPER MISSISSIPPI REGION				
1. Index of industrial production (1954=100)	100	110	118	186
2. Total water intake...billions of gallons per year	114	125	135	212
3. Production...millions of dollars of value added by manufacture in 1959 constant dollars	283	311	335	526
4. Water intake (line 2+line 3)...gallons per dollar of value added	403	403	403	403
5. Number of employees...thousands	22	24	26	41
6. Water use per employee (line 2+line 5)...thousands of gallons	5.2	5.2	5.2	5.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

See footnotes at end of table, p. 66.

***Regional estimate of water use, pulp, paper, and products industry group 26*—Continued**

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
LOWER MISSISSIPPI RIVER REGION				
1. Index of industrial production (1954=100)	100	110	182	762
2. Total water intake.......billions of gallons per year	31	34	56	236
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	92	101	167	701
4. Water intake (line 2÷line 3).......gallons per dollar of value added	337	337	337	337
5. Number of employees.......thousands	6	7	11	45
6. Water use per employee (line 2÷line 5).......thousands of gallons	5.2	5.2	5.2	5.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
UPPER MISSOURI RIVER REGION				
1. Index of industrial production (1954=100)	0	0	0	
2. Total water intake.......billions of gallons per year	0	0	0	195
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	0	0	0	526
4. Water intake (line 2÷line 3).......gallons per dollar of value added				370
5. Number of employees.......thousands	0	0	0	39
6. Water use per employee (line 2÷line 5).......thousands of gallons				5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
LOWER MISSOURI RIVER REGION				
1. Index of industrial production (1954=100)	100	122	310	1,295
2. Total water intake [4].......billions of gallons per year	10	12	31	130
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	27	33	84	350
4. Water intake [4] (line 2÷line 3).......gallons per dollar of value added	370	370	370	370
5. Number of employees.......thousands	2	2	6	26
6. Water use per employee [4] (line 2÷line 5).......thousands of gallons	5	5	5	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
LOWER ARKANSAS-RED AND WHITE RIVERS REGION				
1. Index of industrial production (1954=100)	100	110	230	480
2. Total water intake.......billions of gallons per year	56	62	129	269
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	[6] 146	161	335	701
4. Water intake (line 2÷line 3).......gallons per dollar of value added	384	384	384	384
5. Number of employees.......thousands	11	12	25	53
6. Water use per employee (line 2÷line 5).......thousands of gallons	5.1	5.1	5.1	5.1
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
UPPER ARKANSAS-RED RIVERS REGION				
1. Index of industrial production (1954=100)	0	0	0	
2. Total water intake.......billions of gallons per year	0	0	0	67
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	0	0	0	175
4. Water intake (line 2÷line 3).......gallons per dollar of value added				384
5. Number of employees.......thousands	0	0	0	13
6. Water use per employee (line 2÷line 5).......thousands of gallons				5.1
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
WESTERN GULF REGION				
1. Index of industrial production (1954=100)	100	140	349	731
2. Total water intake.......billions of gallons per year	29	41	101	212
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	[6] 48	67	168	351
4. Water intake (line 2÷line 3).......in gallons per dollar of value added	605	605	605	605
5. Number of employees.......thousands	4	6	14	29
6. Water use per employee (line 2÷line 5).......thousands of gallons	7.3	7.3	7.3	7.3
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				
UPPER RIO GRANDE AND PECOS RIVER REGION				
1. Index of industrial production (1954=100)	0	0	0	
2. Total water intake.......billions of gallons per year	0	0	0	110
3. Production.......millions of dollars of value added by manufacture in 1959 constant dollars	0	0	0	175
4. Water intake (line 2÷line 3).......gallons per dollar of value added	0	0	0	6.3
5. Number of employees.......thousands	0	0	0	14
6. Water use per employee (line 2÷line 5).......thousands of gallons	0	0	0	8.1
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

See footnotes at end of table, p. 66.

***Regional estimate of water use, pulp, paper, and products industry group 26*—Continued**

COLORADO RIVER REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
1. Index of industrial production (1954=100)	100	250	269	17,539
2. Total water intake [4] ... billions of gallons per year	0.5	1	2	88
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	2	5	5	351
4. Water intake [4] (line 2÷line 3) ... gallons per dollar of value added	250	250	250	250
5. Number of employees ... thousands	(5)	(5)	(5)	18
6. Water use per employee [4] (line 2÷line 5) ... thousands of gallons	5	5	5	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

PACIFIC NORTHWEST REGION

Item	1954	1959	1980	2000
1. Index of industrial production (1954=100)	100	158	795	1,557
2. Total water intake ... billions of gallons per year	224	354	1,780	3,487
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	285	450	2,265	4,437
4. Water intake (line 2÷line 3) ... gallons per dollar of value added	786	786	786	786
5. Number of employees ... thousands	17	27	135	265
6. Water use per employee (line 2÷line 5) ... thousands of gallons	13.2	13.2	13.2	13.2
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

GREAT BASIN REGION

Item	1954	1959	1980	2000
1. Index of industrial production (1954=100)	100	250	269	8,769
2. Total water intake [4] ... billions of gallons per year	0.5	1	2	44
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	2	5	5	175
4. Water intake [4] (line 2÷line 3) ... gallons per dollar of value added	250	250	250	250
5. Number of employees ... thousands	(5)	(5)	(5)	9
6. Water use per employee [4] (line 2÷line 5) ... thousands of gallons	5	5	5	5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

CENTRAL PACIFIC REGION

Item	1954	1959	1980	2000
1. Index of industrial production (1954=100)	100	110	255	1,062
2. Total water intake ... billions of gallons per year	13	14	27	115
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 42	46	107	446
4. Water intake (line 2÷line 3) ... gallons per dollar of value added	260	260	260	260
5. Number of employees ... thousands	3	3	8	34
6. Water use per employee (line 2÷line 5) ... thousands of gallons	3.4	3.4	3.4	3.4
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

SOUTH PACIFIC REGION

Item	1954	1959	1980	2000
1. Index of industrial production (1954=100)	100	125	255	1,063
2. Total water intake ... billions of gallons per year	4	6	16	66
3. Production ... millions of dollars of value added by manufacture in 1959 constant dollars	[6] 24	30	61	255
4. Water intake (line 2÷line 3) ... gallons per dollar of value added	260	260	260	260
5. Number of employees ... thousands	2	3	5	19
6. Water use per employee (line 2÷line 5) ... thousands of gallons	3.5	3.5	3.5	3.5
Appropriate comments: National and regional data for 1959, 1980, and 2000 subject to the limitations and qualifications as stated in the accompanying text.				

---

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.

[2] Estimate based on 1958-60 adjustment.

[3] Based on BDSA projection.

[4] 1954 water use data estimated; not provided in MC-209.

[5] Less than 1,000.

[6] 1954 value added data estimated, not provided in MC-209.

Regional distribution of estimated water intake, pulp, paper, and products industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	249	331	588	1,106
Delaware and Hudson	93	102	106	96
Eastern Great Lakes and St. Lawrence	110	137	194	203
Chesapeake Bay	109	174	432	646
Western Great Lakes	142	156	195	244
Ohio	54	60	69	145
Cumberland	2	13	34	70
Tennessee	37	41	74	157
Southeast	329	476	1,281	2,560
Upper Mississippi	114	125	135	212
Lower Mississippi	31	34	56	236
Upper Missouri				195
Lower Missouri	10	12	31	130
Eastern Arkansas-White-Red	56	62	129	269
Western Arkansas-White-Red				67
Western gulf	29	41	101	212
Rio Grande				110
Colorado	.5	1	2	88
Pacific Northwest	224	354	1,780	3,487
Great Basin	.5	1	2	44
Central Pacific	13	14	27	115
South Pacific	4	6	16	66
Total	1,607	2,140	5,252	10,458

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-1960 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional distribution of estimated number of employees, pulp, paper, and products industry group

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	38,000	51,000	90,000	169,000
Delaware and Hudson	26,000	29,000	30,000	27,000
Eastern Great Lakes and St. Lawrence	20,000	25,000	35,000	37,000
Chesapeake Bay	14,000	22,000	55,000	83,000
Western Great Lakes	27,000	30,000	37,000	47,000
Ohio	18,000	20,000	23,000	48,000
Cumberland	(4)	2,000	5,000	10,000
Tennessee	7,000	8,000	14,000	30,000
Southeast	34,000	49,000	132,000	264,000
Upper Mississippi	22,000	24,000	26,000	41,000
Lower Mississippi	6,000	7,000	11,000	45,000
Upper Missouri				39,000
Lower Missouri	2,000	2,000	6,000	26,000
Eastern Arkansas-White-Red	11,000	12,000	25,000	53,000
Western Arkansas-White-Red				13,000
Western gulf	4,000	6,000	14,000	29,000
Rio Grande				14,000
Colorado	(4)	(4)	(4)	18,000
Pacific Northwest	17,000	27,000	135,000	265,000
Great Basin	(4)	(4)	(4)	9,000
Central Pacific	3,000	3,000	8,000	34,000
South Pacific	2,000	3,000	5,000	19,000
Total	252,000	321,000	652,000	1,320,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-1960 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] Less than 1,000.

APPENDIX F. FUTURE WATER REQUIREMENTS FOR THE FOOD AND BEVERAGE INDUSTRIES

INTRODUCTION

The food and beverage processing industries in this study cover the same broad category of SIC group 20 reported in the census of manufacturers, which include those establishments engaged in manufacturing of meat products, dairy products, canning, preserving and freezing, grain-mill products, bakery products, sugar, confectionery and related products, beverages, and miscellaneous food preparations and feed.

The "Census of Manufactures for 1954" reports that the water intake of the food and beverage industries was 677 billion gallons, or 5.6 percent of the total industrial water intake. The major water users in the food and beverage industries defined as those establishments having an intake of 20 million gallons or more per year, accounted for 590 billion gallons, or 5 percent of the total for all industry.

Water requirements estimated for these industries in the years 1980 and 2000, based on RFF median projections, amount to 1,000 billion gallons and 1,500 billion gallons, respectively. Based on BDSA projections the requirements are estimated as 850 and 1,000 billion gallons, respectively, for the same years.

The food and beverage industries utilize water for generating steam, cleaning, peeling, grading, and conveying products. Also, it is used as a heat exchange medium in heating and cooling operations, cleaning plant and equipment, condensing vapors, fire protection, and as an ingredient in finished products.

There is a wide variation in water usage depending on individual company practice such as (1) the extent to which products are flumed rather than mechanically conveyed, (2) methods used in cooling, and (3) extent to which water is recovered and reused. In the canning of peaches, for example, the water required to process 1 ton varies from 1,300 to 13,600 gallons.[1]

The current trend is for processors to replace flumes with conveyor belts as a method to improve their product. This method is credited with a considerable saving over fluming by water of some flavoring constituents and vitamins B and C and minerals.

"Most vegetables and some fruits are blanched. Blanching consists of cooking pieces of food for a short time in water or steam. Small pieces, such as peas, are cooked for about a minute at the boiling temperature or for a slightly longer time at lower temperatures. Larger pieces are cooked longer. The purpose of blanching is to inactivate enzymes and thus enhance the retention of color and flavor during storage.

---

[1] "Water in Food Products Manufacture."

Blanching procedures are not standardized. Some processors have a leaching loss of 5 to 10 percent of each water-soluble vitamin or other constituent. Others have losses of 40 to 50 percent—or even higher with the same food.

Losses are larger in water blanching than in steam blanching and larger with long-low temperature treatment than with quick-high temperature treatment. Industry changed largely to quick-high temperature blanching for frozen green beans, and the color of the product has been greatly improved." [3]

Water used on food and beverage processing should meet U.S. public health standards for potable water. However, the availability of potable water supply has been so ample as to keep the use of it from being a factor of significant concern to these industries. Summed up, most available information on the quantities of water used in individual establishments, and consequently these industries, are estimates. If exact quantities of water used were known, most establishments would effect economies reducing their water usage with no adverse affect or impairment on quality. Considerable research has been conducted to develop electronic blanching to avoid losses through leaching. Although not completely worked out in 1959 the success of this research will enable these industries to considerably reduce their water intake. The engineering knowledge is available when required to reduce the water intake of these industries.

WATER INTAKE AT PLANTS ALSO GENERATING ELECTRICITY

Supplementary information provided by the "Census of Manufactures for 1954" reported establishments generating electricity for their own use in the food and beverage industries numbered 292 or 11 percent of the major water-using establishments. These establishments had a water intake of 37 percent or 219 billion gallons. No data is available on the amount of water utilized in the generation of electricity by these plants. However, it is believed the proportion of water used in generation of electricity relative to the total water used will decrease. New plant or expanded plant production will utilize public power supply.

LOCATION OF PLANTS

The location of major water-using establishments in the food and beverage industries, though not paralleling population, is spread throughout each and every water resource region. While there is no great concentration based on value added in production, employment, and water intake, the water resource regions of most importance in 1954, today, and in the year 2000 are Delaware and Hudson, Western Great Lakes, Upper Mississippi, Ohio, Missouri, and California.

The trend toward mergers in the industries as well as change in areas of farm production are affecting location of new establishments. Naturally, the extent of the trend toward larger size plants or establishments will affect amount of water intake by major water users in the industry. There are no studies reflecting this change in location and the relatives of production employment and water use. Since 2,613 major water users intake for food processing purposes in these industries is less (as generation of electricity is included) than 5 percent of total industrial water intake, possibilities of changes in location (other than that reflected by population shifts) are not considered in this study. The effect would be insignificant.

EMPLOYMENT AND PRODUCTIVITY

The application of new management techniques and the utilization of new more efficient equipment have increased the productivity of workers in food and beverage processing industries. The productivity of workers in selected food and beverage processing industries is shown in the following table (employee productivity index 1947 and 1957 (1947–49 equals 100)):

Industries	1947	1957
Bakery	99	111
Dairy	100	157
Meat	103	111
Canned and frozen	95	138
Sugar	96	143
Grain	99	121

One of the corollaries to increased productivity has been greater use of water per employee as reflected in figures cited above.

This increased productivity and resultant greater use of water per employee is expected to continue through the year 1980 and 2000 and has been reflected in the projections.

FUTURE REQUIREMENTS BASED ON RFF DATA

a. Water intake

(1) *Total.*—The "Census of Manufactures for 1954" reported water intake by food and beverage industries major water-using establishments. This figure was multiplied by factors supplied by RFF and then reduced by factors considered to take account of the reduced water intake of the industry for reasons such as those quoted from the "1959 Agriculture Yearbook—Food." These reductions came to 2 percent for 1959, 5 percent for 1980, and 10 percent for 2000 project water usage of 630 billion gallons; 1,000 billion gallons; and 1,500 billion gallons, respectively, for the indicated years.

(2) *Plants also generating electricity.*—Food and beverage processing industries major water using establishments generating electricity for their own use numbered 292 or 11 percent of the total of all major water using establishments. These establishments had a water intake of 37 percent or 219 billion gallons. Sufficient information was not available on these plants to do other than note this on the na-

---

[3] "The Yearbook of Agriculture, 1959." The U.S. Department of Agriculture, Washington, D.C.

tional summaries and prorate on the basis that any added volume of production would be processed with purchased electricity. Therefore, the greater reduction of water intake in relation to production is on the premise that no additional amounts of electricity will be generated.

b. Production (value added in manufacture in 1959 constant dollars)

The basis for the indexes supplied by RFF were 1947–49 production. Since no water data was available for this period and since water intake data was available for 1954, the base index was converted to 1954 as a base. This was done by a simple ratio formula covering the years involved. The Federal Reserve Board production data were utilized in arriving at these new indexes as follows: 1954 equals 100; 1959 equals 110; 1980 equals 177; and 2000 equals 279.

In order to comply with the instructions to report dollars of value added in production with 1959 constant dollars, adjustment in the dollar values resulting from the above projections were made utilizing the Bureau of Labor Statistics for "Wholesale Price Index—Processed Foods."

These adjustments reveal that the estimates for value added for this industry for the years 1959, 1980, and 2000 would be $7.1 billion, $11.5 billion, and $18.1 billion, respectively.

The water intake per dollar of value added in 1954 for the industries, is estimated at 88, 87, and 83 gallons, respectively, for these same years. Reduction of this amount was made in the projection because conservation of water is being achieved by the industry through fewer applications of water, less water when required, and greater recirculation of water used. While the industry is comprised of many small businesses (in 1954 two-thirds of the plants employed fewer than 20) significant changes in water usage practice is anticipated. The reduction index of water use is expressed in this study with the following factors: 1954 equals 100; 1959 equals 98; 1980 equals 95; and 2000 equals 90.

c. Employment and productivity

The "Census of Manufactures for 1954" reported data on employment in major water using establishments were multiplied by RFF factors for the purpose of obtaining a national summary on employment by the food and beverage industries. Employment in this industry for 1959, 1980, and 2000 was estimated as 700,000, 1 million, and 1,300,000, respectively. On this basis the water intake per employee will rise from 900,000 gallons in 1959 to 1 million in 1980 and 1,153,000 in the year 2000.

FUTURE REQUIREMENTS BASED ON BDSA INDEXES

BDSA requirements were derived in the same way. The only other factor being that instead of taking a proportionate share of the rise in population in adding employees to the industry, productivity is expected to be such as to necessitate only 75 percent of the proportionate population growth.

Comparison of RFF and BDSA—Food and beverage processing industries (SIC–20) major water intake establishments 1954 actual and projected estimates

	1954	1959	1980		2000	
			RFF [1]	BDSA [1]	RFF [1]	BDSA [2]
Index of industrial production	106	116	188	162	296	201
Total water intake, billions of gallons	590	630	1,000	850	1,500	1,000
Plants, General Electric	(219)	(230)	(325)	(270)	(450)	(320)
Production, millions of dollars added in 1959 constant dollars	6,474	7,120	11,458	9,900	18,000	12,300
Water intake per 1959 dollar added, gallons	91	88	87	86	83	81
Number of employees	659,834	700,000	1,000,000	900,000	1,300,000	1,050,000
Water intake per employee, thousands of gallons	894	900	1,000	945	1,153	952

[1] Resources for the Future, Inc.

[2] Business and Defense Services Administration.

METROPOLITAN AREAS

Statistics presented for metropolitan areas report for food and related products industries total amount produced as reflected by value added in manufacture on a 1959 constant dollar basis. They are not comparable to the statistics reported for the region in that regional information reflects only the activity of these industries' major water users (20 million or more gallons intake per year).

The "Census of Manufactures for 1954" reported value added in production was multiplied by the difference in the 1954 and 1959 value of the dollar as reflected by the "Wholesale Price Index for Processed Food." Projections were obtained using 1959's estimate as 100 and multiplying by the projected RFF and BDSA production indexes for the years requested.

National summary of water use, food and beverage industry group

[Tables based on RFF]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	106	116	188	296
Total water intake ... millions of gallons per year	590,000	630,000	1,000,000	1,500,000
Plants also generating electricity	(219)	(230)	(325)	(450)
Production ... millions of dollars added in production in 1959 constant dollars	6,474	7,120	11,458	18,060
Water intake per unit of production ... gallons	91	88	87	83
Number of employees	659,834	700,000	1,000,000	1,300,000
Water use per employee ... thousands of gallons	894	900	1,000	1,153

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional estimate of water use, food and beverage industry group

NEW ENGLAND REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	98	140	195
Total water intake ... millions of gallons per year	21,000	20,000	30,000	41,000
Production ... millions of dollars added in production in 1959 constant dollars	139	136	199	274
Water intake per unit of production ... gallons	155	151	149	148
Number of employees	18,177	16,800	22,000	24,700
Water use per employee ... thousands of gallons	1,155	1,190	1,364	1,660
Production in specified metropolitan areas:				
Boston ... millions of dollars	199	195	279	388
Hartford ... do	23	23	32	45

DELAWARE AND HUDSON REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	105	160	239
Total water intake ... millions of gallons per year	67,000	69,000	105,000	150,000
Production ... millions of dollars added in production in 1959 constant dollars	1,083	1,143	1,745	2,598
Water intake per unit of production ... gallons	62	60	60	59
Number of employees	99,816	101,500	136,500	169,000
Water use per employee ... thousands of gallons	671	680	769	888
Production in specified metropolitan areas:				
New York ... millions of dollars	1,339	1,405	2,142	3,200
Philadelphia ... do	441	463	705	1,054
Albany, Schenectady, and Troy ... do	43	45	69	60

EASTERN GREAT LAKES REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	110	180	295
Total water intake ... millions of gallons per year	23,000	25,000	40,000	61,000
Production ... millions of dollars added in production in 1959 constant dollars	361	403	655	1,047
Water intake per unit of production ... gallons	64	62	61	58
Number of employees	35,351	37,800	55,000	73,450
Water use per employee ... thousands of gallons	650	661	727	831
Production in specified metropolitan areas: Detroit ... millions of dollars	218	240	392	643

CHESAPEAKE REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	115	185	298
Total water intake ... millions of gallons per year	33,000	37,000	59,000	90,000
Production ... millions of dollars added in production in 1959 constant dollars	266	302	493	426
Water intake per unit of production ... gallons	124	123	120	115
Number of employees	36,316	39,900	57,500	76,700
Water use per employee ... thousands of gallons	909	927	1,026	1,173
Production in specified metropolitan areas:				
Washington ... millions of dollars	51	59	94	152
Richmond ... do	28	32	52	83

WESTERN GREAT LAKES REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	110	183	294
Total water intake ... millions of gallons per year	69,000	73,000	114,000	174,000
Production ... millions of dollars added in production in 1959 constant dollars	1,020	1,122	1,786	2,815
Water intake per unit of production ... gallons	68	65	64	62
Number of employees	94,317	100,100	141,500	183,950
Water use per employee ... thousands of gallons	732	729	806	946
Production in specified metropolitan areas:				
Chicago ... millions of dollars	984	1,082	1,800	2,892
Lansing ... do	9	10	16	26

See footnotes at end of table, p. 73.

Regional estimate of water use, food and beverage industry group—Continued

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
OHIO REGION				
Index of industrial production	100	110	175	268
Total water intake ... millions of gallons per year	46,000	50,000	77,000	112,000
Production ... millions of dollars added in production in 1959 constant dollars	675	747	1,181	1,882
Water intake per unit of production ... gallons	68	67	65	60
Number of employees	61,757	65,800	92,000	117,000
Water use per employee ... thousands of gallons	745	760	837	957
Production in specified metropolitan areas:				
Cincinnati ... millions of dollars	169	187	296	453
Indianapolis ... do	92	102	161	247
CUMBERLAND REGION				
Index of industrial production	100	110	160	210
Total water intake ... millions of gallons per year	2,000	2,000	3,000	4,000
Production ... millions of dollars added in production in 1959 constant dollars	23	23	33	43
Water intake per unit of production ... gallons	87	87	83	80
Number of employees	1,500	1,400	2,000	1,950
Water use per employee ... thousands of gallons	1,000	1,100	1,250	1,800
Production in specified metropolitan areas: Nashville ... millions of dollars	40	44	64	84
TENNESSEE REGION				
Index of industrial production	100	103	143	194
Total water intake ... millions of gallons per year	3,000	3,000	4,000	5,000
Production ... millions of dollars added in production in 1959 constant dollars	51	51	71	96
Water intake per unit of production ... gallons	59	59	56	52
Number of employees	3,900	3,780	5,000	5,200
Water use per employee ... thousands of gallons	769	770	800	962
Production in specified metropolitan areas: Chattanooga ... millions of dollars	20	20	28	39
SOUTHEAST REGION				
Index of industrial production	100	110	175	275
Total water intake ... millions of gallons per year	40,000	43,000	67,000	102,000
Production ... millions of dollars added in production in 1959 constant dollars	308	342	540	860
Water intake per unit of production ... gallons	130	126	124	119
Number of employees	33,472	35,700	50,000	65,000
Water use per employee ... thousands of gallons	1,195	1,204	1,340	1,569
Production in specified metropolitan areas:				
Birmingham ... millions of dollars	35	38	61	96
Columbia, S.C ... do	86	95	150	237
UPPER MISSISSIPPI REGION				
Index of industrial production	100	106	162	239
Total water intake ... millions of gallons per year	86,000	89,000	134,000	188,000
Production ... millions of dollars added in production in 1959 constant dollars	898	957	1,461	2,154
Water intake per unit of production ... gallons	96	93	92	87
Number of employees	96,098	98,700	132,000	162,500
Water use per employee ... thousands of gallons	895	911	1,015	1,157
Production in specified metropolitan areas:				
St. Louis ... millions of dollars	322	341	[illegible]	770
Cedar Rapids ... do	21	22	34	50
LOWER MISSISSIPPI REGION				
Index of industrial production	100	101	135	180
Total water intake ... millions of gallons per year	41,000	41,000	60,000	83,000
Production ... millions of dollars added in production in 1959 constant dollars	117	117	159	211
Water intake per unit of production ... gallons	356	355	373	390
Number of employees	13,909	13,300	16,000	16,900
Water use per employee ... thousands of gallons	2,947	3,083	4,511	4,911
Production in specified metropolitan areas: New Orleans ... millions of dollars	109	110	147	196
UPPER MISSOURI REGION				
Index of industrial production	100	101	143	199
Total water intake ... millions of gallons per year	50,000	50,000	74,000	[illegible]
Production ... millions of dollars added in production in 1959 constant dollars	281	284	402	556
Water intake per unit of production ... gallons	179	178	183	188
Number of employees	37,604	36,400	46,000	52,650
Water use per employee ... thousands of gallons	1,329	1,374	1,609	1,994
Production in specified metropolitan areas:				
Denver ... millions of dollars	81	82	115	161
Sioux City ... do	19	19	27	38

See footnotes at end of table, p. 73.

Regional estimate of water use, food and beverage industry group—Continued

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
LOWER MISSOURI REGION				
Index of industrial production	100	95	130	112
Total water intake ... millions of gallons per year	10,000	9,000	13,000	18,000
Production ... millions of dollars added in production in 1959 constant dollars	59	56	77	94
Water intake per unit of production ... gallons	176	171	169	185
Number of employees	9,951	9,100	11,000	11,440
Water use per employee ... thousands of gallons	1,004	904	1,182	1,573
Production in specified metropolitan areas: Kansas City ... millions of dollars	155	147	202	174
LOWER ARKANSAS RED AND WHITE REGION				
Index of industrial production	100	92	108	125
Total water intake ... millions of gallons per year	4,000	4,000	5,000	5,000
Production ... millions of dollars added in production in 1959 constant dollars	39	[illegible]	42	49
Water intake per unit of production ... gallons	117	116	115	110
Number of employees	5,738	5,250	5,500	5,200
Water use per employee ... thousands of gallons	697	762	909	962
Production in specified metropolitan areas: Little Rock ... millions of dollars	11	10	12	14
UPPER ARKANSAS-RED REGION				
Index of industrial production	100	102	150	208
Total water intake ... millions of gallons per year	8,000	8,000	11,000	16,000
Production ... millions of dollars added in production in 1959 constant dollars	52	53	78	108
Water intake per unit of production ... gallons	154	151	147	145
Number of employees	8,370	8,400	10,500	12,350
Water use per employee ... thousands of gallons	955	952	1,048	1,296
Production in specified metropolitan areas:				
Oklahoma City ... millions of dollars	19	19	29	40
Amarillo ... do	31	32	47	64
WESTERN GULF REGION				
Index of industrial production	100	115	193	315
Total water intake ... millions of gallons per year	13,000	15,000	25,000	38,000
Production ... millions of dollars added in production in 1959 constant dollars	184	209	355	578
Water intake per unit of production ... gallons	70	70	70	66
Number of employees	18,542	20,650	31,500	41,730
Water use per employee ... thousands of gallons	701	726	794	911
Production in specified metropolitan areas:				
Houston ... millions of dollars	100	115	193	315
Dallas ... do	92	105	178	290
Fort Worth ... do	81	93	156	255
San Antonio ... do	106	122	205	334
RIO GRANDE AND PECOS REGION				
Index of industrial production	100	115	200	390
Total water intake ... millions of gallons per year	400	430	1,000	2,000
Production ... millions of dollars added in production in 1959 constant dollars	8	9	16	31
Water intake per unit of production ... gallons	52	50	50	50
Number of employees	1,036	1,120	1,800	2,730
Water use per employee ... thousands of gallons	440	440	556	733
Production in specified metropolitan areas: Albuquerque ... millions of dollars	4	5	8	16
COLORADO REGION				
Index of industrial production	100	143	287	500
Total water intake ... millions of gallons per year	2,000	3,000	5,000	8,000
Production ... millions of dollars added in production in 1959 constant dollars	26	32	62	108
Water intake per unit of production ... gallons	95	94	81	74
Number of employees	1,900	2,100	4,000	6,500
Water use per employee ... thousands of gallons	1,100	1,190	1,250	1,300
Production in specified metropolitan areas:				
Phoenix ... millions of dollars	12	17	34	60
Grand Junction ... do	8	11	23	40

See footnotes at end of table, p. 73.

Regional estimate of water use, food and beverage industry group—Continued

PACIFIC NORTHWEST REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	115	191	330
Total water intake ... millions of gallons per year	23,000	26,000	43,000	70,000
Production ... millions of dollars added in production in 1959 constant dollars	203	234	388	650
Water intake per unit of production ... gallons	113	111	111	108
Number of employees	19,378	21,700	32,000	45,500
Water use per employee ... thousands of gallons	1,187	1,198	1,344	1,538
Production in specified metropolitan areas:				
Portland ... millions of dollars	90	104	171	297
Spokane ... do	70	81	138	231

GREAT BASIN REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	125	250	468
Total water intake ... millions of gallons per year	2,000	2,000	5,000	8,000
Production ... millions of dollars added in production in 1959 constant dollars	35	42	81	150
Water intake per unit of production ... gallons	57	57	55	53
Number of employees	2,448	2,800	5,200	8,190
Water use per employee ... thousands of gallons	817	825	961	977
Production in specified metropolitan areas: Salt Lake City ... millions of dollars	20	25	50	94

CENTRAL PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	127	255	465
Total water intake ... millions of gallons per year	34,000	44,000	92,000	162,000
Production ... millions of dollars added in production in 1959 constant dollars	440	560	1,124	2,050
Water intake per unit of production ... gallons	78	78	81	79
Number of employees	38,982	50,400	95,000	144,300
Water use per employee ... thousands of gallons	872	873	969	1,123
Production in specified metropolitan areas: San Francisco ... millions of dollars	408	518	1,040	1,897

SOUTH PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	127	248	450
Total water intake ... millions of gallons per year	13,000	17,000	33,000	58,000
Production ... millions of dollars added in production in 1959 constant dollars	206	262	510	921
Water intake per unit of production ... gallons	65	65	65	63
Number of employees	21,272	27,300	48,000	73,060
Water use per employee ... thousands of gallons	611	623	688	794
Production in specified metropolitan areas: Los Angeles ... millions of dollars	451	572	1,118	2,020

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated water intake and number of employees, food and beverage industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	21	20	30	41
Delaware and Hudson	67	69	105	150
Eastern Great Lakes and St. Lawrence	23	25	40	61
Chesapeake Bay	33	37	59	90
Western Great Lakes	69	73	114	174
Ohio	46	50	77	112
Cumberland	2	2	3	4
Tennessee	3	3	4	5
Southeast	40	43	67	102
Upper Mississippi	86	89	134	188
Lower Mississippi	41	41	60	83
Upper Missouri	50	50	74	105
Lower Missouri	10	9	13	18
Eastern Arkansas-White-Red	4	4	5	5
Western Arkansas-White-Red	8	8	11	16
Western gulf	13	15	25	38
Rio Grande			1	2
Colorado	2	3	5	8
Pacific Northwest	23	26	43	70
Great Basin	2	2	5	8
Central Pacific	34	44	92	162
South Pacific	13	17	33	58
Total	590	630	1,000	1,500

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	18,177	16,800	22,000	24,700
Delaware and Hudson	99,816	101,500	136,500	169,000
Eastern Great Lakes and St. Lawrence	35,351	37,800	55,000	73,450
Chesapeake Bay	36,316	39,900	57,500	76,700
Western Great Lakes	94,317	100,100	141,500	183,950
Ohio	61,757	65,800	92,000	117,000
Cumberland	1,500	1,400	2,000	1,950
Tennessee	3,900	3,780	5,000	5,200
Southeast	33,472	35,700	50,000	65,000
Upper Mississippi	96,098	98,700	132,000	162,500
Lower Mississippi	13,909	13,300	16,000	16,900
Upper Missouri	37,604	36,400	46,000	52,650
Lower Missouri	9,951	9,100	11,000	11,440
Eastern Arkansas-White-Red	5,738	5,250	5,500	5,200
Western Arkansas-White-Red	8,370	8,400	[illegible],500	12,350
Western gulf	18,542	20,650	31,500	41,730
Rio Grande	1,0[illegible]	1,120	1,800	2,730
Colorado	1,900	2,100	4,000	6,500
Pacific Northwest	19,378	21,700	32,000	45,500
Great Basin	2,448	2,800	5,200	8,190
Central Pacific	38,982	50,400	95,000	114,300
South Pacific	21,272	27,300	48,000	73,060
Total	659,834	700,000	1,000,000	1,300,000

[1] From MC-209 "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

National summary of water use, food and beverage industry group

[Tables based on BDSA]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	106	116	162	201
Total water intake—millions of gallons per year	590,000	630,000	850,000	1,000,000
Plants also generating electricity	(219)	(230)	(270)	(320)
Production—millions of dollars added in production in 1959 constant dollars	6,474	7,120	9,900	12,300
Water intake per unit of production—gallons	91	88	86	81
Number of employees	659,834	700,000	9,000,000	105,000
Water use per employee—thousands of gallons	894	900	945	952

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional estimate of water use, food and beverage industry group

NEW ENGLAND REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	98	124	135
Total water intake—millions of gallons per year	21,000	20,000	26,000	28,000
Production—millions of dollars added in production in 1959 constant dollars	139	136	172	187
Water intake per unit of production—gallons	155	151	149	147
Number of employees	18,177	16,800	19,800	19,950
Water use per employee—thousands of gallons	1,155	1,190	1,313	1,404
Production in specified metropolitan areas:				
Boston—millions of dollars	199	195	247	268
Hartford—do	23	23	29	31

DELAWARE AND HUDSON REGION

Item	1954	1959	1980	2000
Index of industrial production	100	105	139	163
Total water intake—millions of gallons per year	67,000	69,000	89,000	100,000
Production—millions of dollars added in production in 1959 constant dollars	1,083	1,143	1,507	1,770
Water intake per unit of production—gallons	62	60	59	56
Number of employees	99,816	101,500	122,850	136,500
Water use per employee—thousands of gallons	671	680	724	733
Production in specified metropolitan areas:				
New York—millions of dollars	1,339	1,405	1,860	2,182
Philadelphia—do	441	463	613	718
Albany, Schnectady, and Troy—do	43	45	103	70

EASTERN GREAT LAKES REGION

Item	1954	1959	1980	2000
Index of industrial production	100	110	157	198
Total water intake—millions of gallons per year	23,000	25,000	34,000	41,000
Production—millions of dollars added in production in 1959 constant dollars	361	403	566	713
Water intake per unit of production—gallons	64	62	60	58
Number of employees	35,351	37,800	49,500	59,300
Water use per employee—thousands of gallons	650	661	687	691
Production in specified metropolitan areas: Detroit—millions of dollars	218	240	342	432

CHESAPEAKE REGION

Item	1954	1959	1980	2000
Index of industrial production	100	115	160	201
Total water intake—millions of gallons per year	33,000	37,000	50,000	60,000
Production—millions of dollars added in production in 1959 constant dollars	266	302	426	535
Water intake per unit of production—gallons	124	123	117	112
Number of employees	36,316	39,900	51,750	62,000
Water use per employee—thousands of gallons	909	927	966	968
Production in specified metropolitan areas:				
Washington—millions of dollars	51	59	82	103
Richmond—do	28	32	45	56

WESTERN GREAT LAKES REGION

Item	1954	1959	1980	2000
Index of industrial production	100	110	150	190
Total water intake—millions of gallons per year	69,000	73,000	99,000	115,000
Production—millions of dollars added in production in 1959 constant dollars	1,020	1,122	1,543	1,917
Water intake per unit of production—gallons	68	65	64	60
Number of employees	94,317	100,100	127,350	148,550
Water use per employee—thousands of gallons	732	729	773	777
Production in specified metropolitan areas:				
Chicago—millions of dollars	984	1,082	1,476	1,870
Lansing—do	9	10	14	17

See footnotes at end of table, p. 77.

Regional estimate of water use, food and beverage industry group—Continued

OHIO REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	110	151	190
Total water intake, millions of gallons per year	46,000	50,000	66,000	75,000
Production, millions of dollars added in production in 1959 constant dollars	675	747	1,021	1,282
Water intake per unit of production, gallons	68	67	65	59
Number of employees	61,757	65,800	82,800	94,500
Water use per employee, thousands of gallons	745	760	791	798
Production in specified metropolitan areas:				
Cincinnati, millions of dollars	169	187	255	321
Indianapolis, do	92	102	139	175
CUMBERLAND REGION				
Index of industrial production	100	110	125	130
Total water intake, millions of gallons per year	2,000	2,000	2,000	2,000
Production, millions of dollars added in production in 1959 constant dollars	23	23	29	29
Water intake per unit of production, gallons	87	87	69	60
Number of employees	1,500	1,400	1,800	1,600
Water use per employee, thousands of gallons	1,000	1,100	1,200	1,300
Production in specified metropolitan areas: Nashville, millions of dollars	40	44	50	52
TENNESSEE REGION				
Index of industrial production	100	103	120	130
Total water intake, millions of gallons per year	3,000	3,000	3,000	3,000
Production, millions of dollars added in production in 1959 constant dollars	51	51	61	65
Water intake per unit of production, gallons	59	59	49	46
Number of employees	3,900	3,780	4,500	4,200
Water use per employee, thousands of gallons	769	770	775	800
Production in specified metropolitan areas: Chattanooga, millions of dollars	20	20	24	26
SOUTHEAST REGION				
Index of industrial production	100	110	150	190
Total water intake, millions of gallons per year	40,000	43,000	57,000	68,000
Production, millions of dollars added in production in 1959 constant dollars	308	342	466	585
Water intake per unit of production, gallons	130	126	122	116
Number of employees	33,472	35,700	45,000	52,500
Water use per employee, thousands of gallons	1,195	1,204	1,267	1,295
Production in specified metropolitan areas:				
Birmingham, millions of dollars	35	38	53	67
Columbia, S.C., do	86	95	129	163
UPPER MISSISSIPPI REGION				
Index of industrial production	100	106	140	163
Total water intake, millions of gallons per year	86,000	89,000	114,000	125,000
Production, millions of dollars added in production in 1959 constant dollars	898	957	1,262	1,466
Water intake per unit of production, gallons	96	93	90	85
Number of employees	96,088	98,700	118,800	131,250
Water use per employee, thousands of gallons	895	911	955	956
Production in specified metropolitan areas:				
Cedar Rapids, millions of dollars	21	22	29	34
St. Louis, do	322	341	451	525
LOWER MISSISSIPPI REGION				
Index of industrial production	100	101	120	125
Total water intake, millions of gallons per year	41,000	41,000	51,000	55,000
Production, millions of dollars added in production in 1959 constant dollars	117	117	138	144
Water intake per unit of production, gallons	356	355	365	377
Number of employees	13,909	13,300	14,400	13,650
Water use per employee, thousands of gallons	2,947	3,083	3,542	4,029
Production in specified metropolitan areas: New Orleans, millions of dollars	109	110	130	136
UPPER MISSOURI REGION				
Index of industrial production	100	101	123	135
Total water intake, millions of gallons per year	50,000	50,000	63,000	70,000
Production, millions of dollars added in production in 1959 constant dollars	281	284	347	379
Water intake per unit of production, gallons	179	178	183	183
Number of employees	37,604	36,400	41,400	42,500
Water use per employee, thousands of gallons	1,329	1,374	1,522	1,647
Production in specified metropolitan areas:				
Denver, millions of dollars	81	82	100	109
Sioux city, do	19	19	23	26

See footnotes at end of table, p. 77.

Regional estimate of water use, food and beverage industry group—Continued

LOWER MISSOURI REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	95	150	108
Total water intake ... millions of gallons per year	10,000	9,000	11,000	12,000
Production ... millions of dollars added in production in 1959 constant dollars	59	56	66	64
Water intake per unit of production ... gallons	176	171	167	178
Number of employees	9,951	9,100	9,900	9,250
Water use per employee ... thousands of gallons	1,004	904	1,111	1,297
Production in specified metropolitan areas: Kansas City ... millions of dollars	155	147	233	167

LOWER ARKANSAS-RED-WHITE REGION

Index of industrial production	100	92	95	33
Total water intake ... millions of gallons per year	4,000	4,000	4,000	4,000
Production ... millions of dollars added in production in 1959 constant dollars	[illegible]	36	37	33
Water intake per unit of production ... gallons	117	116	115	110
Number of employees	5,738	5,250	4,950	4,200
Water use per employee ... thousands of gallons	697	762	808	952
Production in specified metropolitan areas: Little Rock ... millions of dollars	11	10	10	4

UPPER ARKANSAS-RED REGION

Index of industrial production	100	102	130	142
Total water intake ... millions of gallons per year	8,000	8,000	9,000	11,000
Production ... millions of dollars added in production in 1959 constant dollars	52	53	67	74
Water intake per unit of production ... gallons	154	151	141	141
Number of employees	8,370	8,400	9,450	10,000
Water use per employee ... thousands of gallons	955	952	952	1,100
Production in specified metropolitan areas:				
Oklahoma City ... millions of dollars	19	19	25	2[illegible]
Amarillo ... do	31	32	40	44

WESTERN GULF REGION

Index of industrial production	100	115	165	214
Total water intake ... millions of gallons per year	13,000	15,000	21,000	26,000
Production ... millions of dollars added in production in 1959 constant dollars	184	209	307	394
Water intake per unit of production ... gallons	70	70	68	66
Number of employees	18,542	20,650	28,350	33,700
Water use per employee ... thousands of gallons	701	726	741	772
Production in specified metropolitan areas:				
Houston ... millions of dollars	100	115	165	214
Dallas ... do	92	105	152	197
Fort Worth ... do	81	93	134	173
San Antonio ... do	106	122	175	227

RIO GRANDE AND PECOS REGION

Index of industrial production	100	115	175	265
Total water intake ... millions of gallons per year	400	430	1,000	1,000
Production ... millions of dollars added in production in 1959 constant dollars	8	9	14	21
Water intake per unit of production ... gallons	52	50	50	48
Number of employees	1,036	1,120	1,620	2,200
Water use per employee ... thousands of gallons	440	440	500	550
Production in specified metropolitan areas: Albuquerque ... millions of dollars	4	5	7	11

COLORADO REGION

Index of industrial production	100	143	204	285
Total water intake ... millions of gallons per year	2,000	3,000	4,000	6,000
Production ... millions of dollars added in production in 1959 constant dollars	26	32	53	74
Water intake per unit of production ... gallons	95	94	75	81
Number of employees	1,900	2,100	3,600	5,250
Water use per employee ... thousands of gallons	1,100	1,190	1,200	1,240
Production in specified metropolitan areas:				
Phoenix ... millions of dollars	12	17	24	34
Grand Junction ... do	8	11	16	23

PACIFIC NORTHWEST REGION

Index of industrial production	100	115	165	218
Total water intake ... millions of gallons per year	23,000	26,000	36,000	47,000
Production ... millions of dollars added in production in 1959 constant dollars	203	234	336	443
Water intake per unit of production ... gallons	113	111	107	106
Number of employees	19,378	21,700	28,800	36,750
Water use per employee ... thousands of gallons	1,187	1,198	1,250	1,279
Production in specified metropolitan areas:				
Portland ... millions of dollars	90	104	149	196
Spokane ... do	70	81	116	153

See footnotes at end of table, p. 77.

Regional estimate of water use, food and beverage industry group—Continued

GREAT BASIN REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	125	200	291
Total water intake, millions of gallons per year	2,000	2,000	4,000	6,000
Production, millions of dollars added in production in 1959 constant dollars	35	42	70	102
Water intake per unit of production, gallons	57	57	55	54
Number of employees	2,448	2,800	4,680	6,600
Water use per employee, thousands of gallons	817	825	855	909
Production in specified metropolitan areas: Salt Lake City, millions of dollars	20	25	40	58

CENTRAL PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	127	220	317
Total water intake, millions of gallons per year	34,000	44,000	78,000	107,000
Production, millions of dollars added in production in 1959 constant dollars	440	560	970	1,396
Water intake per unit of production, gallons	78	78	80	77
Number of employees	38,982	50,400	85,500	116,550
Water use per employee, thousands of gallons	872	873	912	918
Production in specified metropolitan areas: San Francisco, millions of dollars	408	518	898	1,293

SOUTH PACIFIC REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	127	215	300
Total water intake, millions of gallons per year	13,000	17,000	28,000	38,000
Production, millions of dollars added in production in 1959 constant dollars	206	262	442	627
Water intake per unit of production, gallons	65	65	63	61
Number of employees	21,272	27,300	43,200	59,000
Water use per employee, thousands of gallons	611	623	648	652
Production in specified metropolitan areas: Los Angeles, millions of dollars	451	572	970	1,353

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional distribution of estimated water intake, food and beverage industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	21	20	26	28
Delaware and Hudson	67	69	89	100
Eastern Great Lakes and St. Lawrence	23	25	34	41
Chesapeake Bay	33	37	50	60
Western Great Lakes	69	73	99	115
Ohio	46	50	66	75
Cumberland	2	2	2	2
Tennessee	3	3	3	3
Southeast	40	43	57	68
Upper Mississippi	86	89	114	125
Lower Mississippi	41	41	51	55
Upper Missouri	50	50	63	70
Lower Missouri	10	9	11	12
Eastern Arkansas-White-Red	4	4	4	4
Western Arkansas-White-Red	8	8	9	11
Western gulf	13	15	21	26
Rio Grande	----	----	1	1
Colorado	2	3	4	6
Pacific Northwest	23	26	36	47
Great Basin	2	2	4	6
Central Pacific	34	44	78	107
South Pacific	13	17	28	38
Total	590	630	850	1,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional distribution of estimated number of employees, food and beverage industry group

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	18,177	16,800	19,800	19,950
Delaware and Hudson	99,816	101,500	122,850	136,500
Eastern Great Lakes and St. Lawrence	35,351	37,800	49,500	59,300
Chesapeake Bay	36,316	39,900	51,750	62,000
Western Great Lakes	94,317	100,100	127,350	148,550
Ohio	61,757	65,800	82,800	94,500
Cumberland	1,500	1,400	1,800	1,600
Tennessee	3,900	3,780	4,500	4,200
Southeast	33,472	35,700	45,000	52,500
Upper Mississippi	96,098	98,700	118,800	131,250
Lower Mississippi	13,909	13,300	14,400	13,650
Upper Missouri	37,604	36,400	41,400	42,500
Lower Missouri	9,951	9,100	9,900	9,250
Eastern Arkansas-White-Red	5,738	5,250	4,950	4,200
Western Arkansas-White-Red	8,370	8,400	9,450	10,000
Western gulf	18,542	20,650	28,350	33,700
Rio Grande	1,036	1,120	1,620	2,200
Colorado	1,900	2,100	3,600	5,250
Pacific Northwest	19,378	21,700	28,800	36,750
Great Basin	2,448	2,800	4,680	6,600
Central Pacific	38,982	50,400	85,500	116,550
South Pacific	21,272	27,300	43,200	59,000
Total	659,834	700,000	900,000	1,050,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

APPENDIX G. FUTURE WATER REQUIREMENTS FOR THE ALUMINUM INDUSTRY

INTRODUCTION

This industry encompasses SIC Code 3334 consisting of 21 establishments for the direct reduction of aluminum. The industry increased its total water intake for reduction from 42.5 billion gallons in 1954 to an estimated 57.8 billion gallons in 1959. This increase of more than one-third in 5 years is a reflection of the rapid growth of the industry. By 1980, utilizing the median RFF projections, the industry will require 311 billion gallons and by 2000 the requirements will have soared to 808 billion gallons. These figures do not include water for the generation of privately owned electric power generating plants which are covered separately below.

The average amount of water used in producing a ton of primary aluminum at the present time is about 30,000 gallons. In the accompanying statistics submitted for primary aluminum, the water intake for reduction declines from 29,000 gallons per ton in 1954 to 25,000 gallons per ton in 2000. This decline in the rate of water intake is due primarily to an anticipated increase in the utilization of recirculated water. The amount of water necessary per ton could well be much less than the figure of 25,000 gallons. In a study by the Department of the Interior,[1] it was found that in 1952 water used ranged from 2,500 gallons per ton of aluminum in one plant to about 72,000 gallons per ton in another.

Gas scrubbing is one of the principal uses of water in aluminum reduction plants and the manner in which water is used, cooled, and reused accounts for the large variation in water requirements. The cost of water differs considerably among plants and this cost factor influences the decision whether or not to install facilities for the reuse of water. As water becomes scarce or more costly the water usage for each ton of aluminum production should decrease considerably.

LOCATION OF PLANTS

The 21 aluminum reduction plants are spread over 8 water regions of the United States. The major factor in locating a reduction plant is the cost and availability of electric power. During the large World War II expansion of the aluminum industry, hydroelectric generation of power was used extensively giving particular incentive to growth of the industry in the Pacific Northwest. Recently, the trend has been toward the use of natural gas and coal for the generation of electricity which has brought about an expansion in the Western Gulf and Ohio River areas. Therefore the rise in water consumption during the past 5 years has been the greatest in the latter areas. Should there be an economic breakthrough in other sources of power, such as nuclear reactors, aluminum reduction plants would then look toward other factors in determining locations, such as the proximity of markets. Projections of water requirements for the regions were made on the basis of virtually the same pattern of plant location existing today.

ELECTRIC POWER GENERATION AT PLANTS

A very large amount of water is used by a few plants which generate their own electricity. In 1954, the total water intake (electric generation and reduction of aluminum) for 16 plants was 263 billion gallons, of which 6 plants consumed 245 billion gallons, nearly 95 percent. Approximately 90 percent of this amount, 220 billion gallons, were required in the steam generation of electricity. The accompanying data is divided into two categories of water intake to show that water which is used in the reduction process and that which is used to generate electric power.

Since 1954, the power requirements for the six new reduction plants erected during this period have been purchased from public utility companies or Federal power authorities. However, one plant now under construction will generate its own power using coal as its source of energy.

It is assumed that water intake for the generation of electric power by company-owned facilities will not increase significantly. Current usage is running at 220 billion gallons per year and will increase to 331 billion gallons per year by 2000.

The bulk of future requirements for water used in the generation of electric power for the production of aluminum will be furnished by public utility companies and Federal power authorities.

OTHER BACKGROUND DATA

There has been considerable interest shown recently by domestic producers in overseas operations. Should it prove to be economically feasible with the development of increased world markets, new reduction plants would be constructed in proximity to foreign sources of bauxite. If these plans materialize it would in all probability have an effect on future expansion of domestic reduction plants and would in turn tend to decrease the estimated water requirements in the future. However, no adjustments were made in the projections for such an eventuality.

PRODUCTION

The average growth trend for the production of primary aluminum from 1900 to 1954 was 10.9 percent per year. There is every indication to believe that the future growth rate for aluminum will continue to exceed the average national industrial growth rate. The building, electrical, and transportation industries should account for about 50 percent of aluminum consumption. These industries alone should consume about 2¼ million tons by 1970. Additional markets where aluminum consumption is expected to drastically increase is in containers and packaging and consumer durable goods. Total consumption in all markets is expected to reach 5½ million tons by 1970. This is identical to the index given by Resources for the Future, Inc. It is believed that the trend from 1970 to 2090 given by Resources for the Future is optimistic but not unreasonable. This increased consumption will reflect not only greatly expanded applications in the market areas mentioned above, but also with advanced technology in the field of light metals and the development of entirely new products for which large tonnages of aluminum will be required.

---

[1] "Water Requirements of the Aluminum Industry", Geological Survey Water-Supply Paper 1330-C, 1956, U.S. Government Printing Office, Washington 25, D.C.

Barring the development of low cost, nuclear generated electrical power, coal will probably be the main source of energy for electrical generation. New aluminum facilities will probably purchase rather than generate most of its own electricity. This means that water consumption for the aluminum industry will not rise tremendously, although electric generating facilities will still require large quantities of water.

The index of industrial production used in the national summary was taken from the estimates of Resources for the Future, Inc. Aluminum is the most abundant metal and its potentials are tremendous. It can be anticipated that wide markets will be found in the construction and automotive fields, for example. For this reason BDSA is in agreement with the very large range of potential aluminum production given by Resources for the Future, Inc., which indicates a growth from 2 million tons per year in 1959, to 32 million tons per year in 2000.

FUTURE REQUIREMENTS—WATER

Future water needs to sustain this production will grow from 58 billion gallons per year in 1959 to 311 billion gallons in 1980 and to 808 billion gallons in the year 2000, plus water intake for self-generation of power of 220 billion gallons in 1959 294 in 1980 and 331 in 2000. These figures were derived from applying the median indexes furnished by the RFF. No other adjustments were employed.

National summary of water use, primary aluminum industry group

[Tables based on RFF]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	244	345	2,000	5,400
Water intake:				
(a) Generation of electric power...millions of gallons per year	220,460	220,460	294,060	330,860
(b) Reduction of aluminum...do	42,540	57,820	311,110	807,900
Total	263,000	278,280	605,170	1,138,760
Production (weight added in production)...thousands of short tons	1,460	2,065	11,965	32,300
Water intake per unit of production:				
(a) Generation of electric power...gallons	151,000	106,000	24,600	10,240
(b) Reduction of aluminum...gallons per ton	29,000	28,000	26,000	25,000
Number of employees	20,968	24,866	96,110	199,030
Water use per employee:				
(a) Generation of electric power...thousands of gallons per year	10,514	8,860	3,060	1,660
(b) Reduction of aluminum...do	2,028	2,325	3,237	4,049

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.

[2] Estimate based on 1958-60 adjustment.

[3] Based on median projection supplied by Resources for the Future, Inc.

Regional estimate of water use, primary aluminum industry group

EASTERN GREAT LAKES REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	122	711	1,911
Water intake:				
(a) Generation of electric power...millions of gallons per year	----------	----------	----------	----------
(b) Reduction of aluminum...do	3,567	4,200	22,750	58,750
Production (weight added in production)...thousands of short tons	123	150	875	2,350
Water intake per unit of production:				
(a) Generation of electric power...gallons	----------	----------	----------	----------
(b) Reduction of aluminum...gallons per ton	29,000	28,000	26,000	25,000
Number of employees	2,252	2,600	7,000	14,500
Water use per employee:				
(a) Generation of electric power...thousands of gallons per year	----------	----------	----------	----------
(b) Reduction of aluminum...do	1,584	1,615	3,250	4,050

OHIO RIVER REGION

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	----------	100	567	1,500
Water intake:				
(a) Generation of electric power...millions of gallons per year	----------	----------	36,800	73,600
(b) Reduction of aluminum...do	----------	8,400	44,200	112,500
Total	----------	8,400	81,000	186,100
Production (weight added in production)...thousands of short tons	----------	300	1,700	4,500
Water intake per unit of production:				
(a) Generation of electric power...gallons	----------	----------	21,650	16,350
(b) Reduction of aluminum...gallons per ton	----------	28,000	26,000	25,000
Number of employees	----------	2,700	13,400	27,700
Water use per employee:				
(a) Generation of electric power...thousands of gallons per year	----------	----------	2,800	2,660
(b) Reduction of aluminum...do	----------	3,111	3,298	4,061

See footnotes at end of table, p. 81.

Regional estimate of water use, primary aluminum industry group—Continued

TENNESSEE RIVER REGION

Item	Years			
	1954[1]	1959[2]	1980[3]	2000[3]
Index of industrial production	100	167	703	1,901
Water intake:				
(a) Generation of electric power, millions of gallons per year				
(b) Reduction of aluminum, do.	5,595	9,000	35,100	91,250
Production (weight added in production), thousands of short tons	192	320	1,350	3,650
Water intake per unit of production:				
(a) Generation of electric power, gallons				
(b) Reduction of aluminum, gallons per ton	29,000	28,000	26,000	25,000
Number of employees	3,515	3,866	10,900	22,500
Water use per employee:				
(a) Generation of electric power, thousands of gallons per year				
(b) Reduction of aluminum, do.	1,592	2,320	3,221	4,055

SOUTHEAST REGION

Index of industrial production	100	110	683	1,829
Water intake:				
(a) Generation of electric power, millions of gallons per year				
(b) Reduction of aluminum, do.	1,189	1,260	7,300	18,750
Production (weight added in production), thousands of short tons	41	45	280	750
Water intake per unit of production:				
(a) Generation of electric power, gallons				
(b) Reduction of aluminum, gallons per ton	29,000	28,000	26,000	25,000
Number of employees	780	800	2,260	4,630
Water use per employee:				
(a) Generation of electric power, thousands of gallons per year				
(b) Reduction of aluminum, do.	1,524	1,575	3,230	4,049

LOWER MISSISSIPPI REGION

Index of industrial production	100	114	699	1,891
Total water intake:				
(a) Generation of electric power, millions of gallons per year	70,060	69,260	69,260	69,260
(b) Reduction of aluminum, do.	5,797	6,160	35,100	91,250
Total	75,857	75,420	104,360	160,510
Production (weight added in production), thousands of short tons	193	220	1,350	3,650
Water intake per unit of production:				
(a) Generation of electric power, gallons	366,000	315,000	51,000	18,000
(b) Reduction of aluminum, gallons per ton	29,000	28,000	26,000	25,000
Number of employees	2,350	2,500	10,900	22,500
Water use per employee:				
(a) Generation of electric power, thousands of gallons per year	29,810	27,700	6,300	3,080
(b) Reduction of aluminum, do.	2,466	2,464	3,220	4,055

EASTERN ARKANSAS-RED-WHITE REGION

Index of industrial production	100	101	709	1,892
Total water intake:				
(a) Generation of electric power, millions of gallons per year	53,400	52,800	52,800	52,800
(b) Reduction of aluminum, do.	4,292	4,200	27,300	70,000
Total	57,692	57,000	80,100	122,800
Production (weight added in production), thousands of short tons	148	150	1,050	2,800
Water intake per unit of production:				
(a) Generation of electric power, gallons	361,000	352,000	50,000	19,000
(b) Reduction of aluminum, gallons per ton	29,000	28,000	26,000	25,000
Number of employees	2,480	2,500	8,450	17,200
Water use per employee:				
(a) Generation of electric power, thousands of gallons per year	21,530	21,120	6,250	3,100
(b) Reduction of aluminum, do.	1,730	1,680	3,230	4,069

WESTERN GULF REGION

Index of industrial production	100	120	704	1,920
Total water intake:				
(a) Generation of electric power, millions of gallons per year	97,000	98,400	135,200	135,200
(b) Reduction of aluminum, do.	11,100	9,600	45,760	120,000
Total	108,100	108,000	180,960	255,200
Production (weight added in production), thousands of short tons	250	300	1,760	4,800
Water intake per unit of production:				
(a) Generation of electric power, gallons	388,000	328,000	77,000	28,000
(b) Reduction of aluminum, gallons per ton	44,000	32,000	26,000	25,000
Number of employees	3,898	4,100	14,200	30,000
Water use per employee:				
(a) Generation of electric power, thousands of gallons per year	24,880	24,000	9,520	4,500
(b) Reduction of aluminum, do.	2,850	2,340	3,222	4,000

See footnotes at end of table, p. 81.

Regional estimate of water use, primary aluminum industry group—Continued

PACIFIC NORTHWEST REGION

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	113	702	1,910
Water intake: millions of gallons per year				
(a) Generation of electric power, do.	11,000	15,000	93,600	245,400
(b) Reduction of aluminum				
Production (weight added in production), thousands of short tons	513	580	3,600	9,800
Water intake per unit of production: gallons				
(a) Generation of electric power, gallons per ton	71,000	26,000	26,000	25,000
(b) Reduction of aluminum				
Number of employees	5,893	5,893	29,000	60,000
Water use per employee: thousands of gallons per year				
(a) Generation of electric power, do.	1,950	2,580	3,227	4,090
(b) Reduction of aluminum				

---

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated water intake, aluminum industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England				
Delaware and Hudson				
Eastern Great Lakes and St. Lawrence	3.6	4.2	22.8	58.8
Chesapeake Bay				
Western Great Lakes				
Ohio		8.4	81.0	186.1
Cumberland				
Tennessee	5.6	9.0	35.1	91.3
Southeast	1.2	1.3	7.3	18.8
Upper Mississippi				
Lower Mississippi	75.8	75.4	104.4	160.5
Upper Missouri				
Lower Missouri				
Eastern Arkansas-White-Red	57.7	57.0	80.1	122.8
Western Arkansas-White-Red				
Western gulf	108.1	108.0	181.0	255.2
Rio Grande				
Colorado				
Pacific Northwest	11.0	15.0	93.6	245.4
Great Basin				
Central Pacific				
South Pacific				
Total	263.0	278.3	605.3	1,138.9

---

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional distribution of estimated number of employees, aluminum industry group

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England				
Delaware and Hudson				
Eastern Great Lakes and St. Lawrence	2,252	2,600	7,000	14,500
Chesapeake Bay				
Western Great Lakes				
Ohio		2,700	13,400	27,700
Cumberland				
Tennessee	3,515	3,866	10,900	22,500
Southeast	780	800	2,260	4,630
Upper Mississippi				
Lower Mississippi	2,350	2,500	10,900	22,500
Upper Missouri				
Lower Missouri				
Eastern Arkansas-White-Red	2,480	2,500	8,450	17,200
Western Arkansas-White-Red				
Western gulf	3,898	4,100	14,200	30,000
Rio Grande				
Colorado				
Pacific Northwest	5,693	5,800	29,000	60,000
Great Basin				
Central Pacific				
South Pacific				
Total	20,968	24,866	96,110	199,030

---

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

APPENDIX H. FUTURE WATER REQUIREMENTS FOR THE PRIMARY COPPER INDUSTRY

INTRODUCTION

Water intake for the copper industry in 1954, according to statistics of the Bureau of the Census, was 42 billion gallons. The water intake for this industry in the years 1980 and 2000 will be 114 billion and 247 billion gallons, respectively, based on projections of indexes of industrial production developed by Resources for the Future, Inc.

An alternate estimate of water intake developed by BDSA for the years 1980 and 2000 would be 78 billion and 98 billion gallons.

The primary copper industry (SIC Code 3331) as reported by the "1954 Census of Manufactures," consists of 27 establishments. These establishments are primarily engaged in smelting copper from ore, and in refining copper by electrolytic or other processes. Since this study is concerned with establishments whose annual gross water intake is 20 million gallons and above, it includes 21 of the 27 establishments in the industry. The six eliminated from consideration are also the smallest with respect to number of employees and production capacity.

In this industry blister copper from the smelter becomes the raw material for the refinery (with the exception of imported blister copper which goes directly to the refinery) and hence, largely controls the refinery's amount of end product. For this reason there is extensive duplication when production figures for the two segments of the industry is combined. The comparisons and projections are based on production from primary and secondary sources, and from foreign raw materials. They exclude imported refined metal which increases the overall new supply but does not affect the water usage pattern of smelters or refineries.

WATER USAGE

Geographically, the largest water users in the industry are located in the Delaware and Hudson River water region. There, six establishments, 29 percent of the total establishments, employed 40 percent of the industry's employees and used 25 billion gallons (60 percent) of the total industry water intake. These plants have access to salt water and 24 billion gallons (96 percent) of their 25 billion annual intake was brackish water. There are 2 other establishments which have access to salt water; they accounted for the remaining 4 billion gallons of brackish water intake, a total of 28 billion gallons or 67 percent of the industry's water usage.

Since a large volume (67 percent) of the water used by the industry is brackish (salt) and therefore inexpensive to secure, no curtailment in the amount of water used by this major segment of the industry is foreseen. For this reason water usage is projected in a direct ratio with the index numbers and the rate of production.

ELECTRIC POWER GENERATION

A factor in the water usage picture of this industry is the production of electric power for electrolytic refineries. There are 9 of the 21 establishments which generate their own electric power. These nine plants in 1954 had a water intake of 28 billion gallons or 67 percent of the total. The ratio of water usage per employee in plants which produce their own electricity is nearly double that of plants which purchase electric power from outside sources.

EMPLOYMENT

The employee force however, is projected on a different basis than that for water intake. This projection assumes a tapering-off in the ratio of increased employees to expanded production in order to compensate for the increase in productivity that will accrue from all of the economic forces that are brought in to play. Hence, the alternate projections show a downward trend in rates of employees to production and increases in the amount of water used per employee.

LOCATION OF MILLS

So far as the future for the primary copper industry with respect to any specific location is concerned, it is believed that the inland locations will naturally be the first to feel the squeeze in any future water shortage. Due to the type ore (low copper content) now being mined, the cost of transportation will continue to be a very important consideration. For this reason, it is expected that smelters will continue to be located as near the mines as possible. Domestic refineries might present a different picture—the current U.S. position as a major exporter of refined copper and current or future needs for ready access to incoming materials for processing would stress the seacoast as first choice for future refinery locations. It would follow that such a location would supply a source of adequate and inexpensive brackish water.

The major consideration for the decline of refined copper production from domestic ores in the future would be the availability and copper content of the ore body, rather than the availability of water.

The outlook for increased production of currently produced copper products and for the development of new products using copper is exceedingly good. But copper is probably through its stage of dynamic growth in the United States and should present a picture of stable rather than spectacular progress through the coming years.

METROPOLITAN AREAS

With respect to projections for specified metropolitan areas: In 1954 plants were producing within metropolitan areas in only 2 water resource regions. In these two regions the entire production of the region was within the metropolitan area in question. These production figures are for the entire industry. However, by coincidence typical of this industry, the establishments fall in the 20 million gallon and over group. Obviously, the metropolitan projections follow the regional projections for increase in production.

BDSA ESTIMATES

The RFF estimates of water usage appear to be excessive when consideration is given to the following: (1) the current known copper ore reserves in the United States are only 32.5 million tons; (2) the expectation that per capita consumption of copper in the United States will stay at the current level or decline slightly; and (3) the probability that future expansion in refinery capacity will tend to take place elsewhere in the world near more extensive and higher-grade ore deposits. Therefore, an alternate set of projections has been included in this study placing the estimates at what is believed to be a more realistic level.

The alternate projections employed by the BDSA are based on the following: The median population projection from Resources for the Future Inc., and the 1948–57 average per capita consumption (16.5 pounds of copper per person) give a 1975 usage of 1,865 thousand short tons, 2,021 thousand short tons in 1980, and for the year 2000 a usage figure of 2,731 thousand short tons. The BDSA authority is based on the Engineering and Mining Journal (August 1959 issue) which estimates 1975 U.S. industrial requirements at 2,000 thousand short tons. This compares favorably with the 1975 projection of 1,865 thousand short tons shown above.

Present known copper reserves in the United States are approximately 32.5 million tons; with a depletion rate indicated in the initial projections showing production of 3.5 million tons in 1980 increasing to 7.6 million tons in the year 2000, it is questionable whether or not reserves would last until 2000. Forecasting the depletion of an ore reserve is difficult since new ore reserves usually have a way of being available when needed. At any rate, if ore reserves become insufficient it is a good assumption that future smelters and refineries will be located near foreign sources of ore with the refined copper being shipped to this country.

Any projection of U.S. refinery production to the year 2000 must take into consideration the current trend of U.S. capital toward foreign production facilities. This trend is strong at the present time and in the face of known ore reserves and increasing labor costs could be expected to continue well into the future.

The annual production of refined copper in 1980 and 2000 would be 3.5 million and 7.6 million tons while BDSA projections show production of 2.4 million and 3 million tons for these years.

The following indexes have been taken into consideration in the preparation of this report:

	1954	1959	1980	2000
BDSA index (FRB)	125	150	285	522
Copper division	105	125	191	237
RFF index (FRB)	125	134-161	355	767
RFF-primary copper	104	110	283	612
RFF-minerals	111	117-130	186	279

All the alternate estimates stem directly from 1980 and 2000 projections of U.S. production of refined copper. These are based on production estimates that can reasonably be supported by U.S. ore reserves and supplies of raw materials from foreign sources, estimates of per capita consumption (production is placed above consumption to allow for the export market), and assumptions as to probable future growth.

CONCLUSIONS

It is believed that the future trend in expansion of refinery capacity will be away from the interior of this country and that any major new construction will be located with direct access to the sea. The alternate estimates for 1980 and 2000 for interior regions were lowered by 10 to 30 percent. The estimates for our two seacoast regions were raised by the same percentages. In one of the interior regions (Colorado region) no production of refined copper is shown because water usage and employee force figures were estimated for the smelters located in the area. There are only smelters in this region.

A steady 2.5 to 3 percent annual rate of growth is expected for the primary copper industry between 1960 and 1980, with a reduction to an annual rate of 1.25 to 2 percent between 1980 and 2000.

National summary of water use, primary copper industry group

[Tables based on RFF]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	104	125	283	612
Total water intake ......millions of gallons per year	42, 000	49, 000	114, 000	247, 000
Production ......thousands of short tons	1, 304	1, 563	3, 548	7, 673
Water intake per unit of production ......thousands of gallons per short ton	32	32	32. 1	32. 2
Number of employees	13, 108	15, 000	26, 000	45, 000
Water use per employee ......thousands of gallons per employee	3, 204	3, 300	4, 380	5, 490

[1] From MC-209 "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

Regional estimate of water use, primary copper industry group

DELAWARE AND HUDSON RIVER REGION

[Tables based on RFF]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	131	307	664
Total water intake, millions of gallons per year	25,000	28,600	72,250	158,235
Production, thousands of short tons	[illegible]	820	1,925	4,162
Water intake per unit of production, thousands of gallons per short ton	39.9	34.9	37.5	38
Number of employees	5,169	5,890	10,210	17,670
Water use per employee, thousands of gallons per employee	4,836	4,855	7,073	8,955
Production in specified areas: New York City [4], thousands of short tons	627	820	1,925	4,162

WESTERN GREAT LAKES REGION [5]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	127	264	550
Total water intake, millions of gallons per year	300	400	750	1,555
Production, thousands of short tons	22	28	58	121
Water intake per unit of production, thousands of gallons per short ton	13.6	14.3	13	13
Number of employees	175	225	400	695
Water use per employee, thousands of gallons per employee	1,710	1,780	1,875	2,237

UPPER MISSOURI RIVER REGION [6]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	113	238	523
Total water intake, millions of gallons per year	2,300	2,760	5,500	11,700
Production, thousands of short tons	130	147	310	680
Water intake per unit of production, thousands of gallons per short ton	17.6	18.7	17.7	17.2
Number of employees	350	440	760	1,315
Water use per employee, thousands of gallons per employee	6,570	6,272	7,236	8,900

UPPER RIO GRANDE AND PECOS RIVER REGION [6]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	104	222	473
Total water intake, millions of gallons per year	7,000	8,400	16,500	34,640
Production, thousands of short tons	275	285	610	1,300
Water intake per unit of production, thousands of gallons per short ton	25.5	29.4	27.0	26.6
Number of employees	1,850	2,100	3,640	6,300
Water use per employee, thousands of gallons per employee	3,780	4,000	4,532	5,500

COLORADO REGION [7]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	120	200	437
Total water intake, millions of gallons per year	1,000	1,200	2,000	4,370
Production, thousands of short tons				
Water intake per unit of production, thousands of gallons per short ton				
Number of employees	2,014	2,295	3,980	6,890
Water use per employee, thousands of gallons per employee	500	522	510	634

PACIFIC NORTHWEST REGION [6]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	119	292	674
Total water intake, millions of gallons per year	2,150	2,580	6,500	14,000
Production, thousands of short tons	89	106	260	600
Water intake per unit of production, thousands of gallons per short ton	24.0	24.3	25.0	24.0
Number of employees	1,450	1,650	2,850	4,930
Water use per employee, thousands of gallons per employee	1,483	1,563	2,280	2,839

GREAT BASIN REGION [6]

Item	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	100	111	241	506
Total water intake, millions of gallons per year	4,250	5,100	10,500	22,500
Production, thousands of short tons	160	177	385	810
Water intake per unit of production, thousands of gallons per short ton	26.5	28.8	27.3	27.8
Number of employees	2,100	2,400	4,160	7,200
Water use per employee, thousands of gallons per employee	2,020	2,125	2,524	3,125
Production in specified metropolitan areas: Salt Lake City, thousands of short tons	160	177	385	810

---

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.

[2] Estimate based on 1958-60 adjustment.

[3] Based on median projection supplied by Resources for the Future, Inc.

[4] 2 smelters and 4 refineries in 1959.

[5] 1 refinery and 2 smelters in 1959.

[6] 1 refinery in 1959.

[7] 4 smelters in 1959.

Regional distribution of estimated water intake and number of employees, copper industry group

Region	Water intake in billions of gallons per year			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	25.0	28.6	72.3	158.2
Delaware and Hudson				
Eastern Great Lakes and St. Lawrence				
Chesapeake Bay	.3	.4	.8	1.6
Western Great Lakes				
Ohio				
Cumberland				
Tennessee				
Southeast				
Upper Mississippi				
Lower Mississippi	2.3	2.8	5.5	11.7
Upper Missouri				
Lower Missouri				
Eastern Arkansas-White-Red				
Western Arkansas-White-Red				
Western gulf	7.0	8.4	16.5	34.6
Rio Grande	1.0	1.2	2.0	4.4
Colorado	2.2	2.6	6.5	14.0
Pacific Northwest	4.3	5.1	10.5	22.5
Great Basin				
Central Pacific				
South Pacific				
Total	42.0	49.0	114.0	247.0

Region	Number of employees			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
New England	5,160	5,890	10,210	17,670
Delaware and Hudson				
Eastern Great Lakes and St. Lawrence				
Chesapeake Bay	175	225	400	695
Western Great Lakes				
Ohio				
Cumberland				
Tennessee				
Southeast				
Upper Mississippi				
Lower Mississippi	350	440	760	1,315
Upper Missouri				
Lower Missouri				
Eastern Arkansas-White-Red				
Western Arkansas-White-Red				
Western gulf	1,850	2,100	3,640	6,300
Rio Grande	2,014	2,295	3,980	6,890
Colorado	1,450	1,650	2,850	4,930
Pacific Northwest	2,100	2,400	4,160	7,200
Great Basin				
Central Pacific				
South Pacific				
Total	13,108	15,000	26,000	45,000

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on median projection supplied by Resources for the Future, Inc.

National summary of water use, primary copper industry group

[Tables based on BDSA]

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
Index of industrial production	104	125	191	239
Total water intake, millions of gallons per year	42,000	49,000	78,000	98,000
Production, thousands of short tons	1,304	1,563	2,400	3,000
Water intake per unit of production, thousands of gallons per short ton	32	32	32.5	32.6
Number of employees	13,108	15,000	20,000	23,000
Water use per employee, thousands of gallons per employee	3,204	3,300	3,900	4,260

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional estimate of water use, primary copper industry group

Item	Years			
	1954 [1]	1959 [2]	1980 [3]	2000 [3]
DELAWARE AND HUDSON RIVER REGION				
Index of industrial production	100	131	202	278
Total water intake, millions of gallons per year	25,000	28,560	49,750	67,000
Production, thousands of short tons	628	820	1,270	1,744
Water intake per unit of production, thousands of gallons per short ton	39.8	34.8	39.1	38.4
Number of employees	5,169	5,890	8,500	10,200
Water use per employee, thousands of gallons per employee	4,836	4,848	5,850	6,500
Production in specified metropolitan areas: New York City [4], thousands of short tons	628	820	1,270	1,744
WESTERN GREAT LAKES REGION [5]				
Index of industrial production	100	127	189	173
Total water intake, millions of gallons per year	300	400	495	500
Production, thousands of short tons	22	28	35	38
Water intake per unit of production, thousands of gallons per short ton	13.6	14.3	14.1	13.1
Number of employees	175	225	300	325
Water use per employee, thousands of gallons per employee	1,710	1,780	1,650	1,540
UPPER MISSOURI RIVER REGION [6]				
Index of industrial production	100	113	173	175
Total water intake, millions of gallons per year	2,300	2,760	3,780	4,100
Production, thousands of short tons	130	147	225	228
Water intake per unit of production, thousands of gallons per short ton	17.6	18.7	16.8	17.9
Number of employees	350	440	500	550
Water use per employee, thousands of gallons per employee	6,570	6,272	7,500	7,500
UPPER RIO GRANDE AND PECOS RIVER REGION [7]				
Index of industrial production	100	104	156	175
Total water intake, millions of gallons per year	7,000	8,400	11,000	12,000
Production, thousands of short tons	275	285	430	480
Water intake per unit of production, thousands of gallons per short ton	25.5	29.4	25.0	25.0
Number of employees	1,850	2,100	2,500	3,100
Water use per employee, thousands of gallons per employee	3,780	4,000	4,400	3,900
COLORADO REGION [8]				
Index of industrial production	100	120	157	180
Total water intake, millions of gallons per year	1,000	1,200	1,575	1,800
Production, thousands of short tons				
Water intake per unit of production, thousands of gallons per short ton				
Number of employees	2,014	2,295	3,000	3,225
Water use per employee, thousands of gallons per employee	500	522	525	560
PACIFIC NORTHWEST REGION [6]				
Index of industrial production	100	119	202	258
Total water intake, millions of gallons per year	2,150	2,580	4,290	5,300
Production, thousands of short tons	89	106	180	230
Water intake per unit of production, thousands of gallons per short ton	24.0	24.3	23.8	21.2
Number of employees	1,450	1,650	2,700	3,000
Water use per employee, thousands of gallons per employee	1,483	1,563	1,600	1,800
GREAT BASIN REGION [9]				
Index of industrial production	100	111	163	175
Total water intake, millions of gallons per year	4,250	5,100	7,110	7,300
Production, thousands of short tons	160	177	260	280
Water intake per unit of production, thousands of gallons per short ton	26.5	28.8	27.3	26.0
Number of employees	2,100	2,400	2,500	2,600
Water use per employee, thousands of gallons per short ton	2,020	2,125	2,800	2,800
Production in specified metropolitan areas: Salt Lake City, thousands of short tons	160	177	260	280

---

[1] From MC-209 "Industrial Water Use" 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.
[4] 2 smelters and 4 refineries in 1959.
[5] 1 refinery and 1 smelter in 1959.
[6] 1 refinery.
[7] 1 refinery, 2 smelters.
[8] 4 smelters in 1959.
[9] 2 smelters and 1 refinery in 1959.

Regional distribution of estimated water intake, copper industry group

[Tables based on RFF]

Region	Water intake in billions of gallons per year				Region	Water intake in billions of gallons per year			
	1954[1]	1959[2]	1980[3]	2000[3]		1954[1]	1959[2]	1980[3]	2000[3]
New England					Lower Missouri				
Delaware and Hudson	25.0	28.6	49.8	67.0	Eastern Arkansas-White-Red				
Eastern Great Lakes and St. Lawrence					Western Arkansas-White-Red				
Chesapeake Bay					Western gulf				
Western Great Lakes	.3	.4	.5	.5	Rio Grande	7.0	8.4	11.0	12.0
Ohio					Colorado	1.0	1.2	1.6	1.8
Cumberland					Pacific Northwest	2.2	2.6	4.3	5.3
Tennessee					Great Basin	4.3	5.1	7.1	7.3
Southeast					Central Pacific				
Upper Mississippi					South Pacific				
Lower Mississippi									
Upper Missouri	2.3	2.8	3.8	4.1	Total	42.0	49.0	78.0	98.0

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

Regional distribution of estimated number of employees, copper industry group

[Tables based on BDSA]

Region	Number of employees				Region	Number of employees			
	1954[1]	1959[2]	1980[3]	2000[3]		1954[1]	1959[2]	1980[3]	2000[3]
New England					Lower Missouri				
Delaware and Hudson	5,169	5,890	8,500	10,200	Eastern Arkansas-White-Red				
Eastern Great Lakes and St. Lawrence					Western Arkansas-White-Red				
Chesapeake Bay					Western gulf				
Western Great Lakes	175	225	300	325	Rio Grande	1,850	2,100	2,500	3,100
Ohio					Colorado	2,014	2,295	3,000	3,225
Cumberland					Pacific Northwest	1,450	1,650	2,700	3,000
Tennessee					Great Basin	2,100	2,400	2,500	2,600
Southeast					Central Pacific				
Upper Mississippi					South Pacific				
Lower Mississippi									
Upper Missouri	350	440	500	550	Total	13,108	15,000	20,000	23,000

[1] From MC-209, "Industrial Water Use," 1954 Census of Manufactures.
[2] Estimate based on 1958-60 adjustment.
[3] Based on projection of the FRB index of all industrial production adopted by BDSA.

COMMUNICATIONS

September 2, 1959.

Hon. Fred A. Seaton,
The Secretary of the Interior,
Department of the Interior, Washington, D.C.

My Dear Mr. Secretary: In connection with the work of the Senate Select Committee on National Water Resources, information on industrial use of water has been requested from the Department of Commerce. The staff of that Department has advised that the Bureau of Mines of your Department has the most comprehensive and up-to-date information on use of water in the mineral industries.

Accordingly, we are writing to ask that you furnish the committee with information on water use and future needs for the following mining industry groups: metal, anthracite, bituminous coal and lignite, crude petroleum and natural gas extraction, and nonmetallic minerals (except fuels). We would like in addition to have information on water use for the processing of coal and petroleum products.

We will need the best estimates of water use in these industries available for each of the 22 water resource regions shown on the enclosed map, for the years 1954 and any other recent year for which good data are available that you consider might be useful to the committee, and the best available projections of such water use to the years 1980 and 2000. In making your estimates for 1980 and 2000, it would be helpful if you were to use the assumptions of future economic levels prepared by Resources for the Future, and which are being used by other agencies that are being asked to supply information on water use for various purposes. A copy of selected projections is enclosed along with a listing of metropolitan areas to which specific attention is being given. Resources for the Future will be glad to furnish any other data on assumptions of future economic trends should you so desire.

In preparing the data on water use for each region, we would like to have the following information:

1. Total water intake, except mine water;
2. Total water discharged, except mine water;
3. Mine water intake;
4. Mine water discharged;
5. Gross water use, including recirculation;
6. Source and quality of water intake: surface or ground; fresh, saline, and brackish;
7. The approximate location of the sites of water use, and the quality of the effluent, in order to ascertain the effects of the discharge on the quality of water in the vicinity of the metropolitan areas shown on the enclosed list.

We would appreciate receiving any other information regarding the present and future trends of use of water in mining and the processing of petroleum and coal products that you feel is of consequence. Such items might pertain to significant technological changes foreseeable in the future, special problems of the supply of and demand for water and matters pertaining to pollution and water treatment.

Dr. Nathaniel Wollman of Resources for the Future, and the committee staff, will be available for discussion of any problems that may arise in the preparation of this information.

The committee is most appreciative of the wonderful spirit of cooperation with which the Interior Department has entered into the preparation of material needed for its studies.

Sincerely yours,

Rob't S. Kerr, *Chairman.*

Reproduced from best available copy.

U.S. Department of the Interior,
Office of the Secretary,
Washington, D.C., March 18, 1960.

Hon. Robert S. Kerr,
Chairman, Select Committee on National Water Resources,
U.S. Senate, Washington, D.C.

Dear Senator Kerr: Enclosed are two copies of a report, prepared by the Bureau of Mines, forecasting the "Water Use in the Mineral Industry." Thirty additional copies are being sent to you under separate cover. This report is volume I only, covering the several river basins. Data for the metropolitan areas will be submitted later in volume II.[1]

The section in volume I on metallic and nonmetallic minerals results from preliminary tabulation of returns from a special set of questions included last year in the Bureau of Mines' annual canvass of the producers. The period covered is 1958 rather than 1954. The Bureau has utilized the recent canvass as the basis for its forecast for 1980 and 2000 for the metallic and nonmetallic industries, instead of the data of the Bureau of the Census.

In the case of the fuels industries, Bureau of the Census data were used, since these industries were not included in Mines recent study. Confidentiality rules of Census made forecasting water use for fuels most difficult and, in fact, impractical in some areas.

Sincerely yours,

Royce A. Hardy,
Assistant Secretary of the Interior.

---

[1] Not completed in time to be printed with this report.

WATER USE IN THE MINERAL INDUSTRY

VOLUME I. RIVER BASINS (WATER-USE REGIONS)

PREFACE

Information contained in this report is based on 1954 data from the Bureau of the Census and 1958 data from a Bureau of Mines questionnaire circulated to the mineral industries, except fuels.

In order to have the water-use data broken down by river basins (water-use regions) the Bureau of the Census retabulated the data published in the 1954 census of mineral industries. These data were used as a basis for projecting by river basins the water-use data for the petroleum, anthracite, and bituminous coal industries.

As Bureau of Mines water-use figures were available for the metal and nonmetallic mineral industries, these figures were used in projecting future water demand for metals and nonmetals industries.

Forecasts of water demand were made by each division of the Bureau having responsibility for a segment of the mineral industry. Divisions participating were Minerals, Petroleum and Natural Gas, Anthracite, and Bituminous Coal and Lignite. Using as a basis the latest available figures on water use by the mineral industry, future water demands were forecast taking into account such factors as expected production, population changes, reserves depletion, and technological advances.

The base data for water use by the metals and nonmetals industries are of necessity preliminary, as all information on the returns from the respondents for 1958 has not yet been thoroughly reconciled.

SUMMARY TABLE.—*Water intake by the mineral industry (fresh and brackish) and estimates for 1980 and 2000*

[In millions of gallons]

	1954	1958	1980	2000
Metals	111, 707	82, 493	121, 611	152, 927
Nonmetals	264, 732	206, 875	385, 907	580, 695
Petroleum, production	91, 225	(1)	150, 500	150, 500
Petroleum, refining	1, 220, 000	(1)	2, 891, 000	3, 643, 000
Natural gas—liquid refining	67, 262	(1)	103, 000	103, 000
Oil shale			82, 000	82, 000
Bituminous coal	22, 201	(1)	42, 182	42, 182
Anthracite	14, 527	(1)	8, 500	15, 000
Total	1, 791, 654	(1)	3, 764, 700	4, 769, 304

[1] Not available.

ACKNOWLEDGMENTS

The cooperation of several divisions of the Bureau of Mines made this report possible. In addition to many commodity specialists in the Minerals Division and field offices, particular credit is due Paul M. Buttermore of the Petroleum Division, Dr. W. H. Young of Bituminous Coal, and Forrest T. Moyer of the Anthracite Division, who were largely responsible for the chapters on their respective commodities. The guidance of Leon W. Dupuy of the staff of the Assistant Director, Programs, is also appreciated.

METALS AND NONMETALS

The Division of Minerals conducts a program for about 80 mineral commodities of which about one-third are classed as metals and the remainder nonmetals. As a part of this program mineral statistics are collected and, for 1958, several questions on water use, source, and disposition were included on the general information questionnaire regularly sent to mineral producers. Results of this study have been tabulated by river basins and metropolitan areas and preliminary results are included in this report.

In order to estimate future water demand by the metals and nonmetals industries as realistically as possible, several important users of water among the mineral commodities produced in each river basin were selected to represent the area.

Usually three or four, sometimes as many as seven, commodities accounted for 85 to 95 percent of the water use by mineral commodities in a river basin. Using river basin production figures for such selected commodities and water-use figures for the same commodities a figure representing gallons of water use per ton was computed for each of the selected commodities in the several river basins.

Estimates of water demand by the selected mineral commodities in the several river basins were made for the years 1980 and 2000 based on estimated production of the selected commodities in those years and the gallons of water use per ton.

Estimates for 1980 and 2000 of the total water demand by the metals and nonmetals industries in each river basin were made by increasing estimates for the selected commodities. The forecast for increased water demand was calculated on the basis of knowledge concerning the selected commodities, using the following formula:

$$d=\frac{a}{b/c}$$

a=total water use for all minerals (except fuels) for 1958.

b=water use for selected minerals (except fuels) for 1958.

c=water use for selected minerals (except fuels) for 1980.

d=total water use for all minerals (except fuels) for 1980.

A similar formula was used for the year 2000.

A tabulation of river basin water use by metals and nonmetals industries in 1958 and estimates for 1980 and 2000 are shown in table 1. For comparison the data on water use by the mineral industries, compiled by the Bureau of the Census in 1954, is included. No attempt is made to correlate these data with Bureau of Mines data as different questions were used and procedures for conducting the canvasses were not standardized.

Table 2 contains a breakdown by source of the Bureau's water-use figures for 1958. Table 3 shows a similar tabulation of the Bureau of the Census figures for 1954.

Because of the many deposits and large demand for sand and gravel by the construction industries in all areas, this commodity was the most important user of water in nearly all river basins. Projections of demand for sand and gravel in 1980 and 2000 were based on the product of two factors; one was projections of urban and rural population in the United States, by water resource regions, prepared by Resources of the Future, Inc., the other was an average increase in per capita production of sand and gravel from 1922 to 1958. Water use estimates were calculated from production estimates and a gallons of water use per ton figure for each river basin in 1958.

PETROLEUM AND NATURAL GAS

Information on the water use in the petroleum and natural gas industries was obtained from the 1954 census of mineral industries, the 1954 census of manufacturers, and additional tables furnished by the Bureau of the Census. The data shown are based on information from establishments using 1 million gallons of water or more per year. Table 4 summarizes the 1954 water-use data appearing in tables 5, 6, and 7, and distinguishes between the extraction and processing phases.

In 1954 the processing of crude oil used 78 to 88 percent of the total water intake, discharge, and gross water use in the production and processing of crude petroleum and natural gas. Natural gas liquids required 20.1 percent of the total gross water use.

TABLE 1.—*Water use by metal and nonmetal mining industries 1954 and 1958, and estimates for 1980 and 2000 by river basins*

[In millions of gallons]

River basin	Water use, 1954[1]			Water use, 1958			Water use, 1980			Water use, 2000		
	Metals	Non-metals	Total	Metals	Non-metals	Total	Metals	Non-metals	Total	Metals	Non-metals	Total
1. Arkansas-Red Rivers, upper	1,121	4,094	5,215	1,057	1,623	2,680	1,515	2,369	3,884	1,689	2,643	4,332
2. Arkansas-Red-White Rivers, lower	7,663	4,701	12,364	7,200	4,551	11,751	8,317	5,318	13,635	9,257	5,919	15,176
3. Chesapeake Bay	1,027	13,389	14,416	1,230	9,799	11,029	1,964	15,889	17,853	3,052	24,687	27,739
4. Colorado River	19,272	1,066	20,338	16,347	1,571	17,918	23,316	2,306	25,622	18,075	1,788	19,863
5. Cumberland River	---	213	213	---	252	252	---	422	422	---	619	619
6. Delaware and Hudson Rivers	186	19,857	20,043	2,413	10,947	13,360	3,768	17,164	20,932	5,243	23,883	29,126
7. Great Lakes, eastern	4,439	8,987	13,426	1,133	24,044	25,177	2,067	49,613	51,680	3,835	92,044	95,879
8. Great Lakes, western	19,960	16,445	36,405	7,828	11,705	19,533	13,368	20,052	33,420	20,592	30,888	51,480
9. Great Basin region	25,091	814	25,905	10,572	1,139	11,711	13,941	1,549	15,490	12,834	1,426	14,260
10. Gulf region, western	75	18,601	18,676	960	13,337	14,297	1,664	22,105	23,769	2,421	32,165	34,586
11. Mississippi River, lower	---	9,235	9,235	---	9,905	9,905	---	14,044	14,044	---	17,195	17,195
12. Mississippi River, upper	3,341	20,874	24,215	7,689	33,874	41,563	13,430	61,179	74,609	19,475	88,721	108,196
13. Missouri River, lower	---	801	801	---	1,480	1.480	---	2,559	2,559	---	3,546	3,546
14. Missouri River, upper	2,873	18,783	21,656	3,785	7,693	11,478	7,219	14,656	21,875	6,247	12,683	18,930
15. New England region	---	6,094	6,094	6	1,765	1,771	---	3,050	3,050	---	4,635	4,635
16. Pacific region, central	(2)	9,599	9,599	4,486	15,419	19,905	9,213	30,845	40,058	19,664	65,831	85,495
17. Pacific region, northwest	12,500	(2)	12,500	13,300	2,221	15,521	14,622	2,380	17,002	19,648	3,198	22,846
18. Pacific region, south	119	9,617	9,736	12	6,554	6,566	---	15,992	15,992	---	33,673	33,673
19. Ohio River region	124	22,458	22,582	685	25,014	25,699	1,445	46,693	48,138	2,407	77,868	80,275
20. Rio Grande and Pecos River, upper	2,429	5,320	7,749	2,546	2,433	4,979	3,800	3,650	7,450	5,467	5,253	10,720
21. Southeast region	4,483	55,650	60,133	980	15,106	16,086	1,560	24,448	26,008	2,457	38,492	40,949
22. Tennessee River region	2,369	14,244	16,613	264	6,443	6,707	402	9,624	10,026	564	13,538	14,102
Total	107,072	254,842	361,914	82,493	206,875	289,368	121,611	365,907	487,518	152,927	580,695	733,622

[1] Adapted from 1954 Census of Mineral Industries. Data do not add to totals shown because of concealments.

[2] Not available.

TABLE 2.—*Sources of water used by the mining industry by river basins in 1958*

[In millions of gallons]

River basin	Stream		Lake		Ground		Ocean		Sewage		Other		Total		Total, metals and non-metals
	Metals	Non-metals	Metals	Non-metals	Metals	Non-metals	Metals	Non-metals	Metals	Non-metals	Metals	Non-metals	Metals	Non-metals	
1. Arkansas-Red Rivers, Upper	113	494	28	555	109	506	---	---	---	---	807	68	1,057	1,623	2,680
2. Arkansas-Red-White Rivers, lower	23	2,620	7,080	1,554	97	112	---	---	---	---	---	265	7,200	4,551	11,751
3. Chesapeake Bay	13	4,391	860	360	---	3,814	---	---	---	---	357	1,234	1,230	9,799	11,029
4. Colorado River	1,133	542	743	22	14,464	982	---	---	---	---	2	25	16,347	1,571	17,918
5. Cumberland River	---	252	---	---	---	---	---	---	---	---	---	---	---	252	252
6. Delaware and Hudson Rivers	190	2,626	2	1,972	2,182	5,191	---	216	---	---	39	942	2,413	10,947	13,360
7. Great Lakes, eastern	1,005	6,149	3	9,090	---	6,619	---	---	---	52	125	2,134	1,133	24,044	25,177
8. Great Lakes, western	862	3,622	4,380	4,795	1,032	3.180	---	---	---	2	1,554	106	7,828	11,705	19,533
9. Great Basin region	1,574	368	15	6	8,977	556	---	---	---	---	6	209	10,572	1,139	11,711
10. Gulf region, western	---	6,167	608	60	352	5,444	---	1,475	---	---	---	191	960	13,337	14,297
11. Mississippi River, lower	---	7,690	---	108	1	1,099	---	854	---	---	---	153	1	9,904	9,905
12. Mississippi River, upper	1,038	16,807	4,333	12,760	679	3,963	---	---	---	---	1,639	344	7,689	33,874	41,563
13. Missouri River, lower	---	1,245	---	62	---	166	---	---	---	---	---	7	---	1,480	1,480
14. Missouri River, upper	3,038	3,025	737	3,533	---	952	---	---	---	---	10	183	3,785	7,693	11,478
15. New England region	6	728	---	161	---	595	---	28	---	---	---	253	6	1,765	1,771
16. Pacific region, central	3,792	924	---	22	113	3,132	555	9,277	---	---	26	2,064	4,486	15,419	19,905
17. Pacific region, northwest	11,220	980	2,054	1	11	1,098	---	102	---	---	15	40	13,300	2,221	15,521
18. Pacific region, south	---	27	---	1	12	5,223	---	711	---	1	---	591	12	6,554	6,566
19. Ohio River region	35	14,022	---	4,288	---	4,437	---	---	---	---	650	2,267	685	25,014	25,699
20. Rio Grande and Pecos River, upper	66	276	292	2,025	2,188	132	---	---	---	---	---	---	2,546	2,433	4,979
21. Southeast region	588	6,497	345	4,650	47	3,014	---	900	---	---	---	45	980	15,106	16,086
22. Tennessee River region	---	5,667	255	637	9	118	---	---	---	---	---	21	264	6,443	6,707
Total	24,701	85,119	21,735	46,662	30,273	50,333	555	13,563	---	55	5,230	11,142	82,494	206,874	289,368

TABLE 3.—*Sources of water used in metal and nonmetal mining industries by water-use region in 1954* [1]

[In millions of gallons]

Region	Fresh water intake (except mine water) (water systems)					Water discharged except mine water	Mine water		Gross water use including recirculation [2]
	Total	Public	Company surface	Company ground	Combination and unspecified		Used	Drained and discharged	
1. Arkansas-Red Rivers, upper:									
Metals	1,121	(3)	981	....	(3)	289	253	1,839	4,527
Nonmetals	4,094	(3)	1,380	1,833	(3)	4,050	708	262	7,876
Total	5,215	....	2,361	1,833	....	4,339	961	2,101	12,403
2. Arkansas-Red-White Rivers, lower:									
Metals	7,663	(3)	6,981	415	(3)	6,224	804	1,445	19,635
Nonmetals	4,701	(3)	2,415	426	(3)	4,394	2,114	58	12,683
Total	12,364	....	9,396	841	....	10,618	2,918	1,503	32,318
3. Chesapeake Bay:									
Metals	1,027	....	712	....	315	725	....	490	4,568
Nonmetals	13,389	1,292	....	....	....	13,215	3,195	3,426	30,072
Total	14,416	1,292	712	....	315	13,940	3,195	3,916	34,640
4. Colorado River:									
Metals	19,272	4,253	4,143	7,399	3,477	14,788	2,057	6,188	30,719
Nonmetals	1,066	45	283	501	237	907	72	51	2,052
Total	20,338	4,298	4,426	7,900	3,714	15,695	2,129	6,239	32,771
5. Cumberland River:									
Metals	....	....	....	....	....	....	....	....	....
Nonmetals	213	....	(3)	(3)	23	203	(3)	9	(3)
Total	213	....	....	....	23	203	....	9	....
6. Delaware and Hudson Rivers:									
Metals	186	....	(3)	(3)	....	126	453	1,678	854
Nonmetals	19,857	774	7,932	2,242	8,909	19,037	13,755	19,953	35,556
Total	20,043	774	7,932	2,242	8,909	19,163	14,208	21,631	36,410
7. Great Lakes, eastern:									
Metals	4,439	....	4,439	....	....	4,325	447	924	12,345
Nonmetals	8,987	459	4,049	3,243	1,236	8,627	4,106	2,371	16,412
Total	13,426	459	8,488	3,243	1,236	12,952	4,553	3,295	28,757
8. Great Lakes, western:									
Metals	19,960	(3)	(3)	(3)	....	16,993	1,446	31,112	34,177
Nonmetals	16,445	(3)	(3)	(3)	....	16,097	2,927	3,483	22,260
Total	36,405	....	....	....	....	33,090	4,373	34,595	56,437
9. Great Basin:									
Metals	25,091	67	1,780	4,485	18,759	25,022	1,996	20,940	36,232
Nonmetals	814	46	24	728	16	807	130	476	959
Total	25,905	113	1,804	5,213	18,775	25,829	2,126	21,416	37,191
10. Gulf, western:									
Metals	75	....	....	....	75	70	....	(3)	110
Nonmetals	18,601	3,576	2,109	6,040	6,876	18,179	705	(3)	28,510
Total	18,676	3,576	2,109	6,040	6,951	18,249	705	(3)	28,620
11. Mississippi River, lower:									
Metals	....	....	....	....	....	....	....	....	....
Nonmetals	9,235	11	5,832	2,173	1,219	8,674	1,285	(3)	13,192
Total	9,235	11	5,832	2,173	1,219	8,674	1,285	....	13,192
12. Mississippi River, upper:									
Metals	3,341	9	2,432	896	4	1,540	8,900	24,184	28,680
Nonmetals	[4] 20,874	181	13,842	4,065	[4] 2,786	19,409	[4] 5,452	2,399	35,745
Total	24,215	190	16,274	4,961	2,790	20,949	14,352	26,583	64,425
13. Missouri River, lower:									
Metals	....	....	....	....	....	....	....	....	....
Nonmetals	801	18	592	32	159	798	63	415	940
Total	801	18	592	32	159	798	63	415	940
14. Missouri River, upper:									
Metals	2,873	(3)	2,598	57	(3)	2,303	441	400	6,178
Nonmetals	[4] 18,783	36	3,578	6,949	[4] 8,220	18,414	[4] 1,167	476	57,851
Total	21,656	36	6,176	7,006	8,220	20,717	1,608	876	64,029

See footnotes at end of table, p. 95.

TABLE 3.—*Sources of water used in metal and nonmetal mining industries by water-use region in 1945*—Continued

[In millions of gallons]

Region	Fresh water intake (except mine water) (water systems)					Water discharged except mine water	Mine water		Gross water use including recirculation [2]
	Total	Public	Company surface	Company ground	Combination and unspecified		Used	Drained and discharged	
15. New England:									
Metals	6,094	280	3,630	872	1,312	6,033	1,942	204	10,055
Nonmetals									
Total	6,094	280	3,630	872	1,312	6,033	1,942	204	10,055
16. Pacific, central:									
Metals	(3)	(3)	(3)	90	27	4,450	5,353	2,001	(3)
Nonmetals	9,599	280	4,778	2,335	2,206	9,151	2,169	169	13,888
Total	9,599	280	4,778	2,425	2,233	13,601	7,522	2,170	13,888
17. Pacific, Northwest:									
Metals	12,500	1,307	5,242	163	5,788	10,794	1,973	8,487	15,276
Nonmetals	(3)	(3)	(3)	(3)	991	(3)	1,309	(3)	8,905
Total	12,500	1,307	5,242	163	6,779	10,794	3,282	8,487	24,181
18. Pacific, south:									
Metals	119	22	8	71	18	73	1	1	278
Nonmetals	[4] 9,617	235	129	[4] 8,304	949	9,070	[5] 912	113	11,691
Total	9,736	257	137	8,375	967	9,143	913	114	11,969
19. Ohio River:									
Metals	124	3	(3)	(3)		69	466	(3)	619
Nonmetals	22,458	1,011	13,332	6,721	1,394	21,219	25,429	9,727	67,859
Total	22,582	1,014	13,332	6,721	1,394	21,288	25,895	9,727	68,478
20. Rio Grande and Pecos River:									
Metals	2,429	116	63	2,250		424	(3)	(3)	(3)
Nonmetals	[4] 5,320	39	[4] 2,116	[4] 1,645	1,520	1,596	[5] 14	17	20,462
Total	7,749	155	2,179	3,895	1,520	2,020	14	17	20,462
21. Southeast:									
Metals	4,433	560	1,722	2,098	103	2,184	555	2,599	21,314
Nonmetals	55,650	(3)	18,210	30,351	(3)	55,911	33,838	5,214	173,298
Total	60,133	560	19,932	32,449	103	58,095	34,393	7,813	194,612
22. Tennessee River:									
Metals	2,369	143	(3)		(3)	1,599	232	2,457	3,713
Nonmetals	14,244	165	8,431	3,929	1,719	12,665	1,765	1,353	17,745
Total	16,613	308	8,431	3,929	1,719	14,264	1,997	3,810	21,458
Total, metals [6]	111,707	10,983	53,671	18,080	28,973	92,156	26,074	107,297	240,669
Total, nonmetals [6]	264,732	9,250	113,689	89,789	52,004	253,848	104,360	49,171	586,865
Total, all regions [6]	376,439	20,233	167,360	107,869	80,977	346,004	130,434	156,468	827,534

---

[1] Data from Bureau of Census.

[2] Consists of the following: where recirculation or reuse occurred, the amount of water which have been required if no water had been recirculated or reused, plus water intake and mine water used where no recirculation or reuse occurred.

[3] Not available.

[4] "All regions" total excludes but several regions include mine water used where it was necessary to combine the figures for mine water used and water intake (except mine water) to avoid disclosure of figures for individual companies.

[5] "All regions" total includes but several regions exclude mine water used where it was necessary to combine the figures for mine water used and water intake (except mine water) to avoid disclosure of figures for individual companies.

[6] Data do not add to totals shown because they include water which may not be shown in these categories by river basins for reasons of confidentiality.

TABLE 4.—*Summary of the water intake, discharge, gross, and net water use by the petroleum and natural-gas industries in 1954*

[In millions of gallons]

Water	Extraction, crude petroleum and natural gas	Processing		Total
		Petroleum refining	Natural gas liquids	
Intake:				
Fresh	56,597	655,000	64,267	775,864
Brackish	34,628	565,000	2,995	602,623
Total	91,225	1,220,000	67,262	1,378,487
Discharged:				
Fresh	13,660	(1)	(1)	(1)
Brackish	123,305	(1)	(1)	(1)
Total	136,965	1,111,000	41,714	1,289,679
Gross water use [2]	91,225	4,063,000	1,066,468	5,220,693
Net water use	(1)	109,000	25,548	134,548

[1] Not available.
[2] Includes water intake only.

Following is a short analysis of tables 5, 6, and 7 and shale oil production with a discussion of some of the factors that may affect the use of water in each category in 1980 and 2000.

Table 5: The 91,225 million gallons of water intake for producing crude petroleum and natural gas was only 6.6 percent of the total water intake for both the production and processing of crude petroleum and natural gas. Of the total water intake for production, crude petroleum used about 90 percent, natural gas less than 0.5 percent, drilling wells about 9 percent, and the building, repairing, dismantling of rigs and derricks, and oil and gas field contract services, the remaining 0.5 percent. Of the total fresh water intake about 65 percent came from company ground water systems. About 35 percent of the total fresh water intake and 76 percent of the brackish water intake was used for water flooding. Fresh and brackish water used for water flooding totaled 46.5 billion barrels. Water discharged totaled about 137 billion barrels or about 50 percent more than water intake. Of the total water discharged about 90 percent was brackish and the remainder was fresh.

Table 6: In 1954 petroleum refineries used about 88.5 percent of the total water intake and 86.2 percent of the total water discharged in producing and processing crude petroleum and natural gas. About 54 percent of the total water intake was fresh water, 72 percent of which was from company surface water systems, while the remainder was brackish (salt) water used primarily by refineries at seaboard locations. (See insert map Oil and Gas Journal, Sept. 21, 1959, vol. 57, No. 39, and Refinery Survey, and Bureau of Mines Information Circular 7724.) The average gross water use in refining was about 38 barrels of water per barrel of crude oil processed, but the net water use averaged about one barrel for each barrel of crude processed. Of the total water discharge about 40 percent, or 441 billion barrels, was treated prior to discharge.

It is estimated that total demand for petroleum products may increase to about 7.2 billion barrels in 1980 and 11.8 billion barrels in 2000. This will require a marked increase in petroleum processing in this country. The water used yearly in processing crude petroleum may more than double by 1980. By then crude oil processed may reach 6 billion barrels of which 2.16 billion barrels may be imported. The remainder of the demand for petroleum products will be met with imports.

By 2000 a total of 7.6 billion barrels of crude (26 percent greater than in 1980) may be processed. This may be divided about equally between domestic crude and imported crude. Some of the factors affecting the future use of water in processing of crude petroleum by region include increase or decrease of refining facilities, location of domestic crude production, volume of imports of crude petroleum and refined products and volume and destination of crude oil imports. New systems for cooling refinery products by air instead of by conventional water-cooling systems may decrease markedly water use. It is believed that most new refineries will be built at seaboard locations.

Table 7: Water intake and discharge in natural gas-liquid (LPG) plants in 1954 was only 5 percent and 3 percent respectively of the total intake and discharged in connection with the production and processing of crude petroleum and natural gas. Water discharged was 62 percent of water input; thus the net water used was 38 percent of the input. Ninety-six percent of the total input was fresh water. Most of the remaining 4 percent brackish water input occurred in the lower Mississippi River resource region. Gross water use was over 15 times greater than water intake at natural gasoline plants in contrast to 3.3 times greater at refineries. Gross water use at the natural gasoline plants was fairly high but it was only 26 percent of the total gross water use at the refineries. Only a small portion (2 percent) of the water discharged was treated prior to discharge.

96 a

Table 5. - Water used in crude petroleum and natural gas extraction and contract services 1/, with water use of one million gallons or more, by water resources regions, 1954 2/ and

(Forecasts for 1980 based on 1954 Bureau of the Census water data)

(Millions of gallons)

Region	Year	Total water intake	Total water discharged	Fresh water intake, by source (water system)				Combination and not specified	Intake		Water used for flooding			Water discharged except for flooding			Approximate location of sites of water use
				Public	Company, surface	Company, ground	Combined company surface and ground		Fresh	Brackish	Fresh	Brackish	Total	Fresh	Brackish	Drilling wells and contract services	
New England	1954 1980	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Delaware and Hudson Rivers	1954 1980 4/	N.A. (5)	N.A. (5)	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	Oneida County, N. Y.
Chesapeake Bay	1954 1980 4/	28 50	10 18	(5) -	(5) -	23 -	- -	5 -	28 -	(5) -	28 -	(5) -	28 -	5 -	5 -	(5) -	Steuben County, N. Y.; Potter, Tioga, Cameron, Clinton, Clearfield Counties, Pa.
Southeast	1954 1980 4/	730 400	840 1,500	4 -	74 -	40 -	1 -	22 -	141 -	68 -	5 -	- -	5 -	12 -	828 -	(5) -	Choctaw, Clarke Counties, Ala.; NE & SC Miss.
Eastern Great Lakes	1954 1980 4/	1,897 3,100	678 1,175	19 -	31 -	1,603 -	(5) -	208 -	1,861 -	32 -	1,776 -	30 -	1,806 -	357 -	321 -	(5) -	NC and Western N.Y.; Erie County, Pa.; northern part of Ohio; NE corner Ind.; SE Mich.
Western Great Lakes	1954 1980 4/	465 750	1,120 1,970	16 -	3 -	43 -	(5) -	12 -	74 -	343 -	2 -	219 -	221 -	16 -	1,092 -	12 -	NC and Western Mich.
Ohio River	1954 1980 4/	15,454 22,270	7,986 12,750	101 -	1,731 -	8,369 -	537 -	1,244 -	11,976 -	3,476 -	10,301 -	3,027 -	13,328 -	3,366 -	3,929 -	11 -	Western Pa.; NC & SE Ohio; Ind. except NE corner; E/2 Ill.
Cumberland River	1954 1980 4/	184 200	92 100	1 -	74 -	34 -	23 -	33 -	165 -	18 -	88 -	16 -	104 -	72 -	20 -	(5) -	SC Kentucky; NC Tenn.
Tennessee River	1954 1980 4/	1 5	- 2	- -	1 -	- -	- -	- -	1 -	- -	- -	- -	- -	- -	- -	- -	-
Upper Mississippi River	1954 1980 4/	2,789 4,400	1,618 2,800	4 -	316 -	698 -	154 -	53 -	1,225 -	1,564 -	1,128 -	1,329 -	2,457 -	158 -	1,459 -	1 -	West half of Ill.
Lower Mississippi River	1954 1980 4/	5,241 8,500	20,643 35,000	42 -	743 -	[illegible],557 -	107 -	976 -	4,485 -	759 -	305 -	404 -	709 -	2,036 -	18,574 -	33 -	Western Miss.; Eastern and SE La.
Upper Missouri River	1954 1980 4/	[illegible],273 18,000	5,627 13,000	89 -	2,203 -	668 -	85 -	307 -	3,352 -	1,909 -	559 -	1,611 -	2,170 -	618 -	4,991 -	18 -	E3/4 Mont.; Burke Mt. & Williams counties, N. Dak.; Wyo. except SW/4; W/2 Neb.; and NE/4 Colo.
Lower Missouri River	1954 2/ 1980 4/	138 300	187 450	1 -	7 -	4 -	1 -	4 -	17 -	119 -	11 -	102 -	113 -	17 -	170 -	(5) -	NC Kansas; WC Missouri.
Upper Arkansas - Red Rivers	1954 2/ 1980 4/	20,022 33,000	19,877 32,000	192 -	1,195 -	3,275 -	974 -	830 -	6,466 -	13,558 -	3,110 -	12,186 -	15,296 -	920 -	18,759 -	198 -	W3/4 of S/2 Kan.; Fremont County, Colo.; Panhandle and W3/4 Okla.; Panhandle, N part of NC Tex.
Lower Arkansas - Red and White Rivers	1954 1980 4/	3,774 6,150	8,166 14,000	31 -	255 -	1,207 -	110 -	328 -	1,931 -	1,833 -	543 -	1,574 -	2,117 -	601 -	7,526 -	41 -	SE part of Kan.; E/4 Okla.; WC & SW Ark.; NE part of Tex.; NW, NC La.
Western Gulf	1954 1980 4/	25,445 42,000	44,761 80,000	279 -	990 -	13,274 -	987 -	1,710 -	17,240 -	8,205 -	1,825 -	4,393 -	6,218 -	1,397 -	42,242 -	1,122 -	SW La.; E Gulf Coast, S, WC, and E part of W. Tex.
Upper Rio Grande and Pecos River	1954 1980 4/	4,399 7,200	7,607 13,000	148 -	155 -	2,200 -	142 -	474 -	3,199 -	1,331 -	333 -	713 -	1,046 -	214 -	7,211 -	182 -	W part of W Tex., Chaves, Lea, Eddy Counties, New Mex.
Colorado River	1954 1980 4/	434 960	219 500	12 -	196 -	63 -	7 -	59 -	337 -	4 -	- -	- -	- -	4 -	215 -	(5) -	Moffat, Rio Blanco Counties, Colo.; Carbon, Grand Counties, Utah.
Great Basin	1954 1980 4/	5 25	2 10	(5) -	2 -	3 -	(5) -	(5) -	5 -	(5) -	- -	(5) -	(5) -	(5) -	2 -	(5) -	Uinta, Lincoln Counties, Wyo.
Pacific Northwest	1954 1980 4/	- 40	- 25	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	-
Central Pacific	1954 1980 4/	1,668 2,750	5,561 9,700	192 -	(5) -	886 -	- -	184 -	1,262 -	406 -	29 -	253 -	282 -	233 -	4,870 -	458 -	Kern, Monterey, Fresno, Solano, Sacramento, San Joaquin, Yolo, Sutter, Glenn, Kings, Butte Counties, Calif.
South Pacific	1954 1980 4/	3,799 6,200	12,669 22,000	437 -	(5) -	2,018 -	- -	419 -	2,874 -	925 -	66 -	577 -	643 -	531 -	11,093 -	1,045 -	Santa Barbara, Ventura, Los Angeles & Orange Counties, Calif.
Total	1954	91,285	136,965	1,568	7,936	37,013	3,168	6,868	56,997	34,688	20,109	26,434	46,543	14,537	123,307	3,121	
Total	1980 4/	150,500	240,000	-	-	-	-	-	-	-	-	-	76,796	-	-	-	

NOTE: Gross water use including recirculation is not available.
N.A. - Not available.
1/ Includes drilling oil and gas wells; building, repairing, dismantling rigs and derricks; and oil and gas field contract services, not elsewhere classified.
2/ Breakdown estimated by region since water use in these categories was not reported on a county basis, Bureau of Census data.
3/ Estimates for 2000 expected to approximate those of 1980.
4/ Breakdown not estimated.
5/ Less than 500,000 barrels.

(Face p. 96) No. 1

d in crude petroleum and natural gas extraction and contract services 1/, with water use of one million gallons or more, by water resources regions, 1954 2/ and estimates 1980 3/

96 a

(Forecasts for 1980 based on 1954 Bureau of the Census water data)

(Millions of gallons)

al er rged	Fresh water intake, by source (water system)				Combinations and not specified	Intake		Water used for flooding			Water discharged except for flooding			Approximate location of sites of water use	Estimated crude production (thousand barrels)	Gallons of water per barrel of crude produced	
	Public	Company, surface	Company, ground	Combined company surface and ground		Fresh	Brackish	Fresh	Brackish	Total	Fresh	Brackish	Drilling wells and contract services			Intake	Discharged except water for flooding
- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
A.)	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	N.A. -	Oneida County, N. Y.	N.A. -	N.A. -	N.A. -
10 18	(5) -	(5) -	23 -	- -	5 -	28 -	(5) -	28 -	(5) -	28 -	5 -	5 -	(5) -	Steuben County, N. Y.; Potter, Tioga, Cameron, Clinton, Clearfield Counties, Pa.	49 -	571 -	204 -
0 00	4 -	74 -	40 -	1 -	22 -	141 -	62 -	5 -	- -	5 -	12 -	828 -	(5) -	Choctaw, Clarke Counties, Ala.; NE & SC Miss.	19,662 -	12 -	43 -
75	19 -	31 -	1,603 -	(5) -	208 -	1,861 -	32 -	1,776 -	30 -	1,806 -	357 -	321 -	(5) -	NC and Western N.Y.; Erie County, Pa.; northern part of Ohio; NE corner Ind.; SE Mich.	3,826 -	496 -	177 -
0 0	16 -	3 -	43 -	(5) -	12 -	74 -	343 -	2 -	219 -	221 -	16 -	1,092 -	12 -	NC and Western Mich.	11,876 -	39 -	94 -
	101 -	1,731 -	8,349 -	537 -	1,244 -	11,976 -	3,476 -	10,301 -	3,027 -	13,328 -	3,346 -	3,929 -	11 -	Western Pa.; NC & SE Ohio; Ind. except NE corner; E/2 Ill.	81,389 -	159 -	90 -
	1 -	74 -	32 -	23 -	33 -	163 -	18 -	88 -	16 -	104 -	72 -	20 -	(5) -	SC Kentucky; NC Tenn.	1,379 -	133 -	67 -
	- -	1 -	- -	- -	- -	1 -	- -	- -	- -	- -	- -	- -	- -	-	- -	- -	- -
	4 -	316 -	698 -	154 -	53 -	1,289 -	1,564 -	1,128 -	1,329 -	2,457 -	153 -	1,459 -	1 -	West half of Ill.	24,448 -	114 -	66 -
	42 -	713 -	2,547 -	207 -	976 -	4,485 -	759 -	305 -	404 -	709 -	2,036 -	18,574 -	33 -	Western Miss.; Eastern and SE La.	188,816 -	28 -	109 -
	89 -	2,203 -	668 -	85 -	307 -	3,352 -	1,909 -	559 -	1,611 -	2,170 -	618 -	4,991 -	18 -	E3/4 Mont.; Burke Co. & Williams counties, N. Dak.; Wyo. except SW/4; N/2 Kan.; and NE/4 Colo.	168,120 -	31 -	33 -
	1 -	7 -	4 -	1 -	4 -	17 -	119 -	11 -	102 -	113 -	17 -	170 -	(5) -	NC Kansas; WC Missouri.	2,100 -	66 -	89 -
	192 -	1,195 -	3,275 -	974 -	830 -	6,466 -	13,562 -	3,110 -	12,186 -	15,296 -	920 -	18,759 -	198 -	W3/4 of S/2 Kan.; Fremont County, Colo.; Panhandle and W3/4 Okla.; Panhandle, N part of NC Tex.	342,274 -	58 -	58 -
	31 -	255 -	1,207 -	110 -	328 -	1,931 -	1,633 -	543 -	1,574 -	2,117 -	601 -	7,526 -	41 -	SE part of Kan.; E/4 Okla.; WC & SW Ark.; NE part of Tex.; NW, NE La.	103,958 -	36 -	← 79 -
	279 -	990 -	13,274 -	987 -	1,710 -	17,200 -	8,285 -	1,825 -	4,393 -	6,218 -	1,397 -	42,242 -	1,122 -	SW La.; E Gulf Coast, S, WC, and E part of W. Tex.	782,069 -	33 -	57 -
	148 -	155 -	2,280 -	142 -	474 -	3,199 -	1,331 -	333 -	713 -	1,046 -	214 -	7,211 -	182 -	W part of W Tex., Chaves, Lea, Eddy Counties, New Mex.	194,666 -	23 -	39 -
	12 -	196 -	63 -	7 -	59 -	337 -	4 -	- -	- -	- -	4 -	215 -	(5) -	Moffat, Rio Blanco Counties, Colo.; Carbon, Grand Counties, Utah.	34,397 -	13 -	6 -
	(5) -	2 -	3 -	(5) -	(5) -	5 -	(5) -	- -	(5) -	(5) -	(5) -	2 -	(5) -	Uinta, Lincoln Counties, Wyo.	94 -	53 -	21 -
	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	-	- -	- -	- -0
	292 -	(5) -	886 -	- -	184 -	1,262 -	406 -	29 -	253 -	282 -	233 -	4,870 -	458 -	Kern, Monterey, Fresno, Solano, Sacramento, San Joaquin, Yolo, Sutter, Glenn, Kings, Butte Counties, Calif.	108,574 -	35 -	51 -
	457 -	(5) -	2,018 -	- -	419 -	2,874 -	925 -	66 -	577 -	643 -	531 -	11,093 -	1,045 -	Santa Barbara, Ventura, Los Angeles & Orange Counties, Calif.	247,291 -	15 -	51 -
		7,936	37,013	3,168	6,868	56,597	34,628	20,109	26,434	46,543	10,537	123,307	3,121		2,314,988	39	59
		-	-	-	-	-	-	-	-	76,796	-	-	-		3,474,000	43	69

---

not available.

g, repairing, dismantling rigs and derricks; and oil and gas field contract services, not elsewhere classified.

e in these categories was not reported on a county basis, Bureau of Census data.

those of 1980.

Table 6. - Water used by petroleum refineries with gross intake of 20 million gallons or more, by water resources regions, 1954 and estimates 1980 and 2000

96b

Region	Year	(Billions of gallons)											Crude run to stills (thousands of barrels)	Gallons of wate of cru	
		Total water intake	Total water discharged	Water required if no water was recirculated or used	Intake by source (water system)				Intake brackish (salt) water	Approximate location of sites of water use	Water treated prior to discharge 1/	Net water used		Intake	Disch
					Public	Company, surface	Company, ground	Total							
New England	1954 2/	14	12	15	(3)	(3)	(3)	(3)	14	Boston, Mass. Providence, R. I.	(3)	2	14,511	965	827
	1980 5/	35	28	36	-	-	-	-	-		-	7	-	-	-
	2000 5/	44	35	45	-	-	-	-	-		-	9	-	-	-
Delaware and Hudson Rivers	1954	248	239	465	4	111	1	116	131	New York, Newark, N. J.; Philadelphia, Pa.; Wilmington, Del.	112	9	335,275	740	713
	1980 4/	571	560	1,202	-	-	-	-	-		-	11	-	-	-
	2000 5/	719	706	1,514	-	-	-	-	-		-	13	-	-	-
Chesapeake Bay	1954 2/	36	35	37	1	(3)	(3)	1	35	Baltimore, Md.; Newport News, Va.	(3)	1	21,886	1,645	1,599
	1980 5/	70	68	88	-	-	-	-	-		-	2	-	-	-
	2000 5/	88	86	111	-	-	-	-	-		-	2	-	-	-
Southeast	1954	(3)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-	Birmingham, Mobile, Ala.; Charleston, S.C.; Savannah, Ga.; Hattiesburg, Miss.	-	N.A.	8,456	N.A.	N.A.
	1980 4/	15	14	50	-	-	-	-	-			1	-	-	-
	2000 5/	19	18	63	-	-	-	-	-		-	1	-	-	-
Eastern Great Lakes	1954	49	44	140	4	40	3	47	2	Detroit, Muskegon, Mich.; Toledo, Cleveland, Ohio; Buffalo, N. Y.	13	5	133,546	367	329
	1980 4/	120	104	332	-	-	-	-	-		-	16	-	-	-
	2000 5/	151	131	418	-	-	-	-	-		-	20	-	-	-
Western Great Lakes	1954	136	132	220	30	104	1	135	1	Muskegon & Central Mich.; Gary, Ind.; Duluth, Minn.	50	4	195,877	694	674
	1980 4/	320	313	521	-	-	-	-	-		-	7	-	-	-
	2000 5/	403	394	656	-	-	-	-	-		-	9	-	-	-
Ohio River	1954	51	42	141	1	37	10	48	3	Canton, Cincinnati, Ohio; Catlettsburg, Louisville, Ky.; Indianapolis, Evansville, Ind.; Lawrenceville, Robinson, Ill.	15	9	108,964	468	385
	1980 4/	110	91	334	-	-	-	-	-		-	19	-	-	-
	2000 5/	139	115	421	-	-	-	-	-		-	24	-	-	-
Cumberland River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Nashville, Tenn.; Somerset, Ky.	-	N.A.	286	N.A.	N.A.
	1980 5/	5	4	15	-	-	-	-	-		-	1	-	-	-
	2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-
Tennessee River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	-	-	N.A.			
	1980 5/	5	4	15	-	-	-	-	-			1	-	-	-
	2000 5/	6	5	19	-	-	-	-	-			1	-	-	-
Upper Mississippi River	1954	19	15	126	1	10	7	18	1	Minneapolis, Minn.; E. St. Louis, Salem, Pana, Ill.	3	4	92,896	205	161
	1980 4/	50	39	299	-	-	-	-	-		-	11	-	-	-
	2000 5/	63	49	377	-	-	-	-	-		-	14	-	-	-
Lower Mississippi River	1954	66	63	235	(3)	54	10	64	2	Memphis, Tenn.; Yazoo City, Miss.; Baton Rouge, New Orleans, La.	1	3	135,152	488	466
	1980 4/	155	147	557	-	-	-	-	-		-	8	-	-	-
	2000 5/	195	185	702	-	-	-	-	-		-	10	-	-	-
Upper Missouri River	1954 2/	22	17	80	2	14	4	20	2	Bismark, Williston, N. Dak.; Billings, Great Falls, Cut Bank, Shelby, Mont.; Casper, Cheyenne, Rawlins, Thermoplis, Husky, Wyo.; Scotts Bluff, Neb.; Denver, Colo.; Kansas City, Kan.	5	5	83,605	263	203
	1980 5/	50	40	190	-	-	-	-	-		-	10	-	-	-
	2000 5/	63	50	239	-	-	-	-	-		-	13	-	-	-
Lower Missouri River	1954 2/	6	5	22	(3)	4	1	5	1	Kansas City, Mo.	2	1	23,435	256	213
	1980 5/	15	12	28	-	-	-	-	-		-	3	-	-	-
	2000 5/	19	15	35	-	-	-	-	-		-	4	-	-	-
Upper Arkansas-Red Rivers	1954 2/	20	8	408	6	6	7	19	1	Wichita, McPherson, El Dorado, Kan.; Amarillo, Pampa, Borger, Wichita Falls, Tex.; Ponca City, Enid, Cushing, Ardmore, Okla.	3	12	170,649	117	47
	1980 5/	50	17	967	-	-	-	-	-		-	33	-	-	-
	2000 5/	63	21	1,218	-	-	-	-	-		-	42	-	-	-
Lower Arkansas-Red and White Rivers	1954 2/	8	3	177	2	3	3	8	(3)	Neodesha, Coffeyville, Kan.; El Dorado, Ark.; Mt. Pleasant, Tex.; Shreveport, Haynesville, La.	2	5	74,255	108	40
	1980 5/	20	7	419	-	-	-	-	-		-	13	-	-	-
	2000 5/	25	9	528	-	-	-	-	-		-	16	-	-	-
Western Gulf	1954 2/	376	347	1,444	30	82	27	139	230	Lake Charles, La.; Gulfport, Houston, Texas City, Bay City, Corpus Christi, San Antonio, Tyler, Longview, Dallas, Ft. Worth, Graham, Abilene, Big Spring, Midland, Texas.	142	29	722,791	520	480
	1980 4/	860	822	3,563	-	-	-	-	-		-	38	-	-	-
	2000 5/	1,085	1,037	4,491	-	-	-	-	-		-	48	-	-	-
Upper Rio Grande and Red River	1954	9	9	36	1	2	1	4	5	Artesia, Monument, New Mex.; Alamosa, Colo.	4	-	17,994	500	500
	1980 4/	25	21	85	-	-	-	-	-		-	4	-	-	-
	2000 5/	32	26	107	-	-	-	-	-		-	6	-	-	-
Colorado River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Farmington, Gallup, N. Mex.; Rangley, Colo.; Jensen, Utah.	-	N.A.	1,504	N.A.	N.A.
	1980 5/	5	4	15	-	-	-	-	-		-	1	-	-	-
	2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-
Great Basin	1954	N.A.	N.A.	N.A.	-	-	-	-	-	Salt Lake City, Utah.	-	N.A.	26,008	N.A.	N.A.
	1980 4/	5	4	15	-	-	-	-	-		-	1	-	-	-
	2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-
Pacific Northwest	1954	(3)	(3)	(3)	-	-	-	-	-	Seattle, Bellingham, Wash.; Portland, Oregon.	-	(3)	-	-	-
	1980 4/	5	4	15	-	-	-	-	-		-	1	-	-	-
	2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-
Central Pacific	1954 2/	63	55	174	4	2	3	9	54	San Francisco, Coalinga, Bakersfield, Calif.	35	8	148,617	424	370
	1980 5/	150	130	308	-	-	-	-	-		-	20	-	-	-
	2000 5/	190	164	388	-	-	-	-	-		-	26	-	-	-
South Pacific	1954 2/	95	83	263	7	2	5	14	81	Santa Maria, Ventura, Los Angeles, Long Beach, Calif.	53	12	223,857	424	371
	1980 5/	250	200	623	-	-	-	-	-		-	50	-	-	-
	2000 5/	315	252	785	-	-	-	-	-		-	63	-	-	-
Others 5/	1954	[illegible]	[illegible]	[illegible]											

Table 6. - Water used by petroleum refineries with gross intake of 20 million gallons or more, by water resources regions, 1954 and estimates 1980 and 2000

96 b

(Millions of gallons)															
Total water intake	Total water discharged	Water required if no water was recirculated or used	Intake by source (water system)				Intake brackish (salt) water	Approximate location of sites of water use	Water treated prior to discharge 1/	Net water used	Crude run to stills (thousands of barrels)	Gallons of water used per barrel of crude processed			
			Public	Company, surface	Company, ground	Total						Intake	Discharge	Gross	Net
14 35 44	12 28 35	15 36 45	(3) - -	(3) - -	(3) - -	(3) - -	14 - -	Boston, Mass. Providence, R. I.	(3) - -	2 7 9	14,511 - -	965 - -	827 - -	1,034 - -	138 - -
248 571 719	239 560 706	465 1,202 1,514	4 - -	111 - -	1 - -	116 - -	131 - -	New York, Newark, N. J.; Philadelphia, Pa.; Wilmington, Del.	112 - -	9 11 13	335,275 - -	740 - -	713 - -	1,387 - -	27 - -
36 70 88	35 68 86	37 88 111	1 - -	(3) - -	(3) - -	1 - -	35 - -	Baltimore, Md.; Newport News, Va.	(3) - -	1 2 2	21,886 - -	1,645 - -	1,599 - -	1,691 - -	46 - -
(3) 15 19	N.A. 14 18	N.A. 50 63	N.A. - -	N.A. - -	N.A. - -	N.A. - -	- - -	Birmingham, Mobile, Ala.; Charleston, S.C.; Savannah, Ga.; Hattiesburg, Miss.	- -	N.A. 1 1	8,456 - -	N.A. - -	N.A. - -	N.A. - -	N.A. - -
49 120 151	44 104 131	140 332 418	4 - -	40 - -	3 - -	47 - -	2 - -	Detroit, Muskegon, Mich.; Toledo, Cleveland, Ohio; Buffalo, N. Y.	13 - -	5 16 20	133,546 - -	367 - -	329 - -	1,048 - -	37 - -
136 320 403	132 313 394	220 521 656	30 - -	104 - -	1 - -	135 - -	1 - -	Muskegon & Central Mich.; Gary, Ind.; Duluth, Minn.	50 - -	4 7 9	195,877 - -	694 - -	674 - -	1,123 - -	20 - -
51 110 139	42 91 115	141 334 421	1 - -	37 - -	10 - -	48 - -	3 - -	Canton, Cincinnati, Ohio; Catlettsburg, Louisville, Ky.; Indianapolis, Evansville, Ind.; Lawrenceville, Robinson, Ill.	15 - -	9 19 24	108,964 - -	468 - -	385 - -	1,294 - -	83 - -
N.A. 5 6	N.A. 4 5	N.A. 15 19	- - -	- - -	- - -	- - -	- - -	Nashville, Tenn.; Somerset, Ky.	- - -	N.A. 1 1	286 - -	N.A. - -	N.A. - -	N.A. - -	N.A. - -
N.A. 5 6	N.A. 4 5	N.A. 15 19	- - -	- - -	- - -	- - -	- - -	-	-	N.A. 1 1	- - -	- - -	- - -	- - -	- - -
19 50 63	15 39 49	126 299 377	1 - -	10 - -	7 - -	18 - -	1 - -	Minneapolis, Minn.; E. St. Louis, Salem, Pana, Ill.	3 - -	4 11 14	92,896 - -	205 - -	161 - -	1,356 - -	43 - -
66 155 195	63 147 185	235 557 702	(3) - -	54 - -	10 - -	64 - -	2 - -	Memphis, Tenn.; Yazoo City, Miss.; Baton Rouge, New Orleans, La.	1 - -	3 8 10	135,152 - -	488 - -	466 - -	1,739 - -	22 - -
22 50 63	17 40 50	80 190 239	2 - -	14 - -	4 - -	20 - -	2 - -	Bismark, Williston, N. Dak.; Billings, Great Falls, Cut Bank, Shelby, Mont.; Casper, Cheyenne, Rawlins, Thermopolis, Husky, Wyo.; Scotts Bluff, Neb.; Denver, Colo.; Kansas City, Kan.	5 - -	5 10 13	83,605 - -	263 - -	203 - -	957 - -	60 - -
6 15 19	5 12 15	22 28 35	(3) - -	4 - -	1 - -	5 - -	1 - -	Kansas City, Mo.	2 - -	1 3 4	23,435 - -	256 - -	213 - -	939 - -	43 - -
20 50 63	8 17 21	408 967 1,218	6 - -	6 - -	7 - -	19 - -	1 - -	Wichita, McPherson, El Dorado, Kan.; Amarillo, Pampa, Borger, Wichita Falls, Tex.; Ponca City, Enid, Cushing, Ardmore, Okla.	3 - -	12 33 42	170,649 - -	117 - -	47 - -	2,391 - -	70 - -
8 20 25	3 7 9	177 419 528	2 - -	3 - -	3 - -	8 - -	(3) - -	Neodesha, Coffeyville, Kan.; El Dorado, Ark.; Mt. Pleasant, Tex.; Shreveport, Haynesville, La.	2 - -	5 13 16	74,255 - -	108 - -	40 - -	2,384 - -	67 - -
376 860 1,085	347 822 1,037	1,444 3,563 4,491	30 - -	82 - -	27 - -	139 - -	230 - -	Lake Charles, La.; Gulfport, Houston, Texas City, Bay City, Corpus Christi, San Antonio, Tyler, Longview, Dallas, Ft. Worth, [illegible], Abilene, Big Spring, Midland, Texas.	142 - -	29 38 48	722,791 - -	520 - -	480 - -	1,998 - -	38 - -
9 25 32	9 21 26	36 85 107	1 - -	2 - -	1 - -	4 - -	5 - -	Artesia, Monument, New Mex.; Alamosa, Colo.	4 - -	- 4 6	17,994 - -	500 - -	500 - -	2,001 - -	N.A. - -
N.A. 5 6	N.A. 4 5	N.A. 15 19	- - -	- - -	- - -	- - -	- - -	Farmington, Gallup, N. Mex.; Rangley, Colo.; Jensen, Utah.	- - -	N.A. 1 1	1,504 - -	N.A. - -	N.A. - -	N.A. - -	N.A. - -
N.A. 5 6	N.A. 4 5	N.A. 15 19	- - -	- - -	- - -	- - -	- - -	Salt Lake City, Utah.	- - -	N.A. 1 1	26,008 - -	N.A. - -	N.A. - -	N.A. - -	N.A. - -
(3) 5 6	(3) 4 5	(3) 15 19	- - -	- - -	- - -	- - -	- - -	Seattle, Bellingham, Wash.; Portland, Oregon.	- - -	(3) 1 1	- - -	- - -	- - -	- - -	- - -
63 150 190	55 130 164	174 308 388	4 - -	2 - -	3 - -	9 - -	54 - -	San Francisco, Coalinga, Bakersfield, Calif.	35 - -	8 20 26	148,617 - -	424 - -	370 - -	1,171 - -	54 - -
95 250 315	83 200 252	263 623 785	7 - -	2 - -	5 - -	14 - -	81 - -	Santa Maria, Ventura, Los Angeles, Long Beach, Calif.	53 - -	12 50 63	223,857 - -	424 - -	371 - -	1,175 - -	54 - -
2	2	100	7	-	1	8	2		1	-	-	-	-	-	N.A.
[illegible]	1,111	4,080	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								

Southeast	1954	(3)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-	Birmingham, Mobile, Ala.; Charleston, S.C.; Savannah, Ga.; Hattiesburg, Miss.	-	N.A.	
	1980 4/	15	14	50	-	-	-	-	-			1	
	2000 4/	19	18	63	-	-	-	-	-		-	1	
Eastern Great Lakes	1954	49	44	140	4	40	3	47	2	Detroit, Muskegon, Mich.; Toledo, Cleveland, Ohio; Buffalo, N. Y.	13	5	13
	1980 4/	120	104	332	-	-	-	-	-		-	16	
	2000 4/	151	131	418	-	-	-	-	-		-	20	
Western Great Lakes	1954	136	132	220	30	104	1	135	1	Muskegon & Central Mich.; Gary, Ind.; Duluth, Minn.	50	4	19
	1980 4/	320	313	521	-	-	-	-	-		-	-	
	2000 4/	403	394	656	-	-	-	-	-		-	9	
Ohio River	1954	51	42	141	1	37	10	48	3	Canton, Cincinnati, Ohio; Catlettsburg, Louisville, Ky.; Indianapolis, Evansville, Ind.; Lawrenceville, Robinson, Ill.	15	9	10
	1980 4/	110	91	334	-	-	-	-	-		-	19	
	2000 4/	139	115	421	-	-	-	-	-		-	24	
Cumberland River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Nashville, Tenn.; Somerset, Ky.	-	N.A.	
	1980 4/	5	4	15	-	-	-	-	-		-	1	-
	2000 4/	6	5	19	-	-	-	-	-		-	1	-
Tennessee River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	-	-	N.A.	-
	1980 4/	5	4	15	-	-	-	-	-			1	-
	2000 4/	6	5	19	-	-	-	-	-			1	-
Upper Mississippi River	1954	19	15	126	1	10	7	18	1	Minneapolis, Minn.; E. St. Louis, Salem, Pana, Ill.	3	4	92,
	1980 4/	50	39	299	-	-	-	-	-		-	11	-
	2000 4/	63	49	377	-	-	-	-	-		-	14	-
Lower Mississippi River	1954	66	63	235	(3)	54	10	64	2	Memphis, Tenn.; Yazoo City, Miss.; Baton Rouge, New Orleans, La.	1	3	135,1
	1980 4/	155	147	557	-	-	-	-	-		-	8	-
	2000 4/	195	185	702	-	-	-	-	-		-	10	-
Upper Missouri River	1954 2/	22	17	80	2	14	4	20	2	Bismark, Williston, N. Dak.; Billings, Great Falls, Cut Bank, Shelby, Mont.; Casper, Cheyenne, Rawlins, Thermopolis, Husky, Wyo.; Scotts Bluff, Neb.; Denver, Colo.; Kansas City, Kan.	5	5	83,0
	1980 4/	50	40	190	-	-	-	-	-		-	10	-
	2000 4/	63	50	239	-	-	-	-	-		-	13	-
Lower Missouri River	1954 2/	6	5	22	(3)	4	1	5	1	Kansas City, Mo.	2	1	23,43
	1980 4/	15	12	28	-	-	-	-	-		-	3	-
	2000 4/	19	15	35	-	-	-	-	-		-	4	-
Upper Arkansas-Red Rivers	1954 2/	20	8	408	6	6	7	19	1	Wichita, McPherson, El Dorado, Kan.; Amarillo, Pampa, Borger, Wichita Falls, Tex.; Ponca City, Enid, Cushing, Ardmore, Okla.	3	12	170,6
	1980 4/	50	17	967	-	-	-	-	-		-	33	-
	2000 4/	63	21	1,218	-	-	-	-	-		-	42	-
Lower Arkansas-Red and White Rivers	1954 2/	8	3	177	2	3	3	8	(3)	Neodesha, Coffeyville, Kan.; El Dorado, Ark.; Mt. Pleasant, Tex.; Shreveport, Haynesville, La.	2	5	74,255
	1980 4/	20	7	419	-	-	-	-	-		-	13	-
	2000 4/	25	9	528	-	-	-	-	-		-	16	-
Western Gulf	1954 2/	376	347	1,444	30	82	27	139	230	Lake Charles, La.; Gulfport, Houston, Texas City, Bay City, Corpus Christi, San Antonio, Tyler, Longview, Dallas, Ft. Worth, Graham, Abilene, Big Spring, Midland, Texas.	142	29	722,791
	1980 4/	860	822	3,563	-	-	-	-	-		-	38	-
	2000 4/	1,085	1,037	4,491	-	-	-	-	-		-	48	-
Upper Rio Grande and Red River	1954	9	9	36	1	2	1	4	5	Artesia, Monument, New Mex.; Alamosa, Colo.	4	-	17,994
	1980 4/	25	21	85	-	-	-	-	-		-	4	-
	2000 4/	32	26	107	-	-	-	-	-		-	6	-
Colorado River	1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Farmington, Gallup, N. Mex.; Rangley, Colo.; Jensen, Utah.	-	N.A.	1,504
	1980 4/	5	4	15	-	-	-	-	-		-	1	-
	2000 4/	6	5	19	-	-	-	-	-		-	1	-
Great Basin	1954	N.A.	N.A.	N.A.	-	-	-	-	-	Salt Lake City, Utah.	-	N.A.	26,008
	1980 4/	5	4	15	-	-	-	-	-		-	1	-
	2000 4/	6	5	19	-	-	-	-	-		-	1	-
Pacific Northwest	1954	(3)	(3)	(3)	-	-	-	-	-	Seattle, Bellingham, Wash.; Portland, Oregon.	-	(3)	-
	1980 4/	5	4	15	-	-	-	-	-		-	1	-
	2000 4/	6	5	19	-	-	-	-	-		-	1	-
Central Pacific	1954 2/	63	55	174	4	2	3	9	54	San Francisco, Coalinga, Bakersfield, Calif.	35	8	148,617
	1980 4/	150	130	308	-	-	-	-	-		-	20	-
	2000 4/	190	164	388	-	-	-	-	-		-	26	-
South Pacific	1954 2/	95	83	263	7	2	5	14	81	Santa Maria, Ventura, Los Angeles, Long Beach, Calif.	53	12	223,857
	1980 4/	250	200	623	-	-	-	-	-		-	50	-
	2000 4/	315	252	785	-	-	-	-	-		-	63	-
Others 5/	1954	2	2	100	7	-	1	8	2		1	-	-
Total	1954	1,220	1,111	4,083	100	471	84	655	565		141	109	2,539,564
Total	1980 4/	2,891	2,633	9,677	-	-	-	-	-		-	258	6,020,300
Total	2000 4/	3,643	3,318	12,193	-	-	-	-	-		-	325	7,598,200

N.A. - Not available.

1/ Includes simple as well as complex treatment.

2/ Entries for entire region estimated, Bureau of Census data.

3/ Less than 500 million gallons.

4/ Breakdown not estimated.

5/ Region not specified; refineries with gross intake of less than 20 million barrels of water.

[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	Philadelphia, Pa.;	-	11	335,275	740	713	1,387	27
2000 5/	719	706	1,514	-	-	-	-	-	Wilmington, Del.	-	13	-	-	-	-	-
1954 2/	36	35	37	1	(3)	(3)	1	35	Baltimore, Md.; Newport News, Va.	(3)	1	21,886	1,645	1,599	1,691	46
1980 5/	70	68	88	-	-	-	-	-		-	2	-	-	-	-	-
2000 5/	88	86	111	-	-	-	-	-		-	2	-	-	-	-	-
1954	(3)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-	Birmingham, Mobile, Ala.; Charleston, S.C.; Savannah, Ga.; Hattiesburg, Miss.	-	N.A.	8,456	N.A.	N.A.	N.A.	N.A.
1980 4/	15	14	50	-	-	-	-	-		-	1	-	-	-	-	-
2000 5/	19	18	63	-	-	-	-	-		-	1	-	-	-	-	-
1954	49	44	140	4	40	3	47	2	Detroit, Muskegon, Mich.; Toledo, Cleveland, Ohio; Buffalo, N. Y.	13	5	133,546	367	329	1,048	37
1980 4/	120	104	332	-	-	-	-	-		-	16	-	-	-	-	-
2000 5/	151	131	418	-	-	-	-	-		-	20	-	-	-	-	-
1954	136	132	220	30	104	1	135	1	Muskegon & Central Mich.; Gary, Ind.; Duluth, Minn.	50	4	195,877	694	674	1,123	20
1980 4/	320	313	521	-	-	-	-	-		-	7	-	-	-	-	-
2000 5/	403	394	656	-	-	-	-	-		-	9	-	-	-	-	-
1954	51	42	141	1	37	10	48	3	Canton, Cincinnati, Ohio; Catlettsburg, Louisville, Ky.; Indianapolis, Evansville, Ind.; Lawrenceville, Robinson, Ill.	15	9	108,964	468	385	1,294	83
1980 4/	110	91	334	-	-	-	-	-		-	19	-	-	-	-	-
2000 5/	139	115	421	-	-	-	-	-		-	24	-	-	-	-	-
1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Nashville, Tenn.; Somerset, Ky.	-	N.A.	286	N.A.	N.A.	N.A.	N.A.
1980 5/	5	4	15	-	-	-	-	-		-	1	-	-	-	-	-
2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-	-	-
1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	-	-	N.A.	-	-	-	-	-
1980 5/	5	4	15	-	-	-	-	-			1	-	-	-	-	-
2000 5/	6	5	19	-	-	-	-	-			1	-	-	-	-	-
1954	19	15	126	1	10	7	18	1	Minneapolis, Minn.; E. St. Louis, Salem, Pana, Ill.	3	4	92,896	205	161	1,356	43
1980 4/	50	39	299	-	-	-	-	-		-	11	-	-	-	-	-
2000 5/	63	49	377	-	-	-	-	-		-	14	-	-	-	-	-
1954	66	63	235	(3)	54	10	64	2	Memphis, Tenn.; Yazoo City, Miss.; Baton Rouge, New Orleans, La.	1	3	135,152	488	466	1,739	22
1980 4/	155	147	557	-	-	-	-	-		-	8	-	-	-	-	-
2000 5/	195	185	702	-	-	-	-	-		-	10	-	-	-	-	-
1954 2/	22	17	80	2	14	4	20	2	Bismark, Williston, N. Dak.; Billings, Great Falls, Cut Bank, Shelby, Mont.; Casper, Cheyenne, Rawlins, Thermopolis, Husky, Wyo.; Scotts Bluff, Neb.; Denver, Colo.; Kansas City, Kan.	5	5	83,605	263	203	957	60
1980 5/	50	40	190	-	-	-	-	-		-	10	-	-	-	-	-
2000 5/	63	50	239	-	-	-	-	-		-	13	-	-	-	-	-
1954 2/	6	5	22	(3)	4	1	5	1	Kansas City, Mo.	2	1	23,435	256	213	939	43
1980 5/	15	12	28	-	-	-	-	-		-	3	-	-	-	-	-
2000 5/	19	15	35	-	-	-	-	-		-	4	-	-	-	-	-
1954 2/	20	8	403	6	6	7	19	1	Wichita, McPherson, El Dorado, Kan.; Amarillo, Pampa, Borger, Wichita Falls, Tex.; Ponca City, Enid, Cushing, Ardmore, Okla.	3	12	170,649	117	47	2,391	70
1980 5/	50	17	967	-	-	-	-	-		-	33	-	-	-	-	-
2000 5/	63	21	1,218	-	-	-	-	-		-	42	-	-	-	-	-
1954 2/	8	3	177	2	3	3	8	(3)	Neodesha, Coffeyville, Kan.; El Dorado, Ark.; Mt. Pleasant, Tex.; Shreveport, Haynesville, La.	2	5	74,255	108	40	2,384	67
1980 5/	20	7	419	-	-	-	-	-		-	13	-	-	-	-	-
2000 5/	25	9	528	-	-	-	-	-		-	16	-	-	-	-	-
1954 2/	376	347	1,444	30	82	27	139	230	Lake Charles, La.; Gulfport, Houston, Texas City, Bay City, Corpus Christi, San Antonio, Tyler, Longview, Dallas, Ft. Worth, Graham, Abilene, Big Spring, Midland, Texas.	147	29	722,791	520	480	1,998	38
1980 4/	860	822	3,563	-	-	-	-	-		-	38	-	-	-	-	-
2000 5/	1,085	1,037	4,491	-	-	-	-	-		-	48	-	-	-	-	-
1954	9	9	36	1	2	1	4	5	Artesia, Monument, New Mex.; Alamosa, Colo.	4	-	17,994	500	500	2,001	N.A.
1980 4/	25	21	85	-	-	-	-	-		-	4	-	-	-	-	-
2000 5/	32	26	107	-	-	-	-	-		-	6	-	-	-	-	-
1954 4/	N.A.	N.A.	N.A.	-	-	-	-	-	Farmington, Gallup, N. Mex.; Rangley, Colo.; Jensen, Utah.	-	N.A.	1,504	N.A.	N.A.	N.A.	N.A.
1980 5/	5	4	15	-	-	-	-	-		-	1	-	-	-	-	-
2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-	-	-
1954	N.A.	N.A.	N.A.	-	-	-	-	-	Salt Lake City, Utah.	-	N.A.	26,008	N.A.	N.A.	N.A.	N.A.
1980 4/	5	4	15	-	-	-	-	-		-	1	-	-	-	-	-
2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-	-	-
[illegible]	(3)	(3)	(3)	-	-	-	-	-	Seattle, Bellingham, Wash.; Portland, Oregon.	-	(3)	-	-	-	-	-
1980 4/	5	4	15	-	-	-	-	-		-	1	-	-	-	-	-
2000 5/	6	5	19	-	-	-	-	-		-	1	-	-	-	-	-
1954 2/	63	55	174	4	2	3	9	54	San Francisco, Coalinga, Bakersfield, Calif.	35	8	148,617	424	370	1,171	54
1980 5/	150	130	308	-	-	-	-	-		-	20	-	-	-	-	-
2000 5/	190	164	388	-	-	-	-	-		-	26	-	-	-	-	-
1954 2/	95	83	263	7	2	5	14	81	Santa Maria, Ventura, Los Angeles, Long Beach, Calif.	53	12	223,857	424	371	1,175	54
1980 5/	250	200	623	-	-	-	-	-		-	50	-	-	-	-	-
2000 5/	315	252	785	-	-	-	-	-		-	63	-	-	-	-	-
54	2	2	100	7	-	1	8	2		1	-	-	-	-	-	N.A.
54	1,220	1,111	4,083	100	471	84	655	565		441	109	2,539,564	480	437	1,608	43
0 4/	2,891	2,633	9,677	-	-	-	-	-		-	258	6,020,300	-	-	-	-
0 4/	3,643	3,318	12,193	-	-	-	-	-		-	325	7,598,200	-	-	-	-

well as complex treatment.
region estimated, Bureau of Census data.
lion gallons.
mated.
ed; refineries with gross intake of less than 20 million barrels of water.

Table 7 - Water use by natural gas-liquid plants 1/ reporting 1 million gallons or more by water use regions, 1954 and estimat
(Forecasts for 1980 based on 1954 Bureau of Census water data)

(Millions of gallons)

Region	Year	Total water intake	Total water discharged	Gross water use including recirculation	Fresh water intake by source (water system): Public	Company, surface	Company, ground	Total	Brackish water intake	Approximate location of sites of water use	Water treated prior to discharge 1/	Net water used
New England	1980 3/	-	-	-	-	-	-	-	-	-	-	-
Delaware and Hudson Rivers	1980 3/	-	-	-	-	-	-	-	-	-	-	-
Chesapeake Bay	1954 4/ 1980 5/	6/ 6/	6/ 6/	6/ 6/	- -	- -	- -	- -	- -	- -	- -	- -
Southeast	1954 4/ 1980 5/	288 475	210 255	3,421 5,400	15 -	- -	273 -	288 -	-	Cranfil, Gwinville, Brookhaven, Miss.	- -	78 120
Eastern Great Lakes	1954 5/ 1980 5/	6/ 6/	6/ 6/	6/ 6/	- -	- -	- -	- -	- -	- -	- -	N.A. -
Western Great Lakes	1954 1980 5/	18 25	13 20	211 330	1 -	- -	17 -	18 -	- -	Mt. Pleasant, Mich.	- -	5 5
Ohio River	1954 1980 5/	9,491 14,000	9,155 13,600	79,815 123,000	78 -	9,215 -	198 -	9,491 -	- -	West half of W. Va., Franklin & Pittsburgh, Pa., Cleveland, Ohio, Robinson, Ill.	56 -	336 500
Cumberland River	1980 3/	-	-	-	-	-	-	-	-	-	-	-
Tennessee River	1980 3/	-	-	-	-	-	-	-	-	-	-	-
Upper Mississippi River	1954 5/ 1980 5/	6/ 6/	6/ 6/	6/ 6/	- -	- -	- -	- -	- -	- -	- -	N.A. -
Lower Mississippi River	1954 4/ 1980 5/	26,415 39,000	24,893 27,300	73,545 113,300	27 -	14,738 -	8,749 -	23,514 -	2,901 -	Jefferson, St. Charles, St. Mary, Iberville, St. Landry & Tensas Counties, La.	339 -	1,522 2,300
Upper Missouri River	1954 4/ 1980 5/	650 2,000	168 970	8,942 13,400	- -	293 -	357 -	650 -	- -	Glacier County, Mont., Park, Washakie, Fremont, Weston, Michrara, Johnson, Carbon, Kimball, Cheyenne Counties, Wyo.; Logan, Morgan, Washington Counties, Colo.	- -	482 700
Lower Missouri River	1980 3/	-	-	-	-	-	-	-	-	-	-	-
Upper Arkansas-Red Rivers	1954 4/ 1980 5/	3,337 5,500	689 1,100	165,223 253,000	227 -	321 -	2,783 -	3,331 -	6 -	SW Kansas; Eastern Okla.; Panhandle, & NC Texas.	22 -	2,648 4,000
Lower Arkansas-Red & White Rivers	1954 1980 5/	889 1,300	272 400	21,173 31,700	- -	12 -	877 -	889 -	- -	NE Texas; NW & NC La.; & SW Ark.	- -	617 940
Western Gulf	1954 1980 5/	20,866 32,000	5,121 7,800	499,218 754,000	922 -	757 -	19,166 -	20,845 -	21 -	SW La.; E, SE, S, NC, WC & W. Texas.	404 -	15,745 24,000
Upper Rio Grande and Pecos River	1954 1980 5/	2,852 4,300	920 1,500	80,419 121,000	482 -	1 -	2,369 -	2,852 -	- -	Eddy, Lea Counties, SE New Mexico.	15 -	1,932 2,940
Colorado River	1954 5/ 1980 5/	N.A. 400	N.A. 300	N.A. 6,300	- -	- -	- -	- -	- -	Moffat, Rio Blanco Counties, Colo.; Daggett County, Utah, Sweetwater County, Wyo., San Juan, McKinley Counties, New Mex.	- -	N.A. 100
Great Basin	1954 1980 5/	- 200	- 150	- 3,700	- -	- -	- -	- -	- -	Uinta County, Wyo.	- -	- 50
Pacific Northwest	1954 1980 5/	- 100	- 75	- 1,900	- -	- -	- -	- -	- -	-	- -	- 25
Central Pacific	1954 4/ 1980 5/	1,199 1,800	121 185	61,580 93,370	76 -	- -	1,060 -	1,136 -	63 -	Fresno, Kings, San Luis Obispo and Kern Counties, Calif.	- -	1,078 1,645
South Pacific	1954 4/ 1980 5/	1,257 1,900	152 245	52,421 79,600	788 -	4 -	461 -	1,253 -	4 -	Santa Barbara, Ventura, Los Angeles, Orange Counties, Calif.	44 -	1,105 1,675
Total	1954	67,262	41,714	1,046,468	2,616	25,341	36,310	64,267	2,995		880	25,548
Total	1980 5/	103,000	64,000	1,600,000	-	-	-	-	-		-	39,000

N.A. - Not available.
1/ Consists of natural gasoline and cycle condensate.
2/ Estimates for 2000 expected to approximate those of 1980.
3/ None reported for 1954 and none expected in 1980.
4/ Entries for entire region estimated.
5/ Breakdown not estimated.
6/ Less than 500,000 gallons.

ble 7 - Water use by natural gas-liquid plants 1/ reporting 1 million gallons or more by water use regions, 1954 and estimates for 1980 2/
(Forecasts for 1980 based on 1954 Bureau of Census water data)

96c

(Millions of gallons)

Gross water use including recirculation	Fresh water intake by source (water system): Public	Fresh water intake by source (water system): Company, surface	Fresh water intake by source (water system): Company, ground	Fresh water intake by source (water system): Total	Brackish water intake	Approximate location of sites of water use	Water treated prior to discharge 1/	Net water used	Natural gas processed (millions of cubic feet)	Gallons of water per thousand cubic feet of gas processed: Intake	Gallons of water per thousand cubic feet of gas processed: Discharge	Gallons of water per thousand cubic feet of gas processed: Gross water use
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
6/ 5/	- -	- -	- -	- -	- -	- -	- -	- -	115 -	- -	- -	- -
3,421 5,400	15 -	- -	273 -	288 -	-	Grenfil, Gwinville, Brookhaven, Miss.	- -	78 120	80,189 -	3.6 -	2.6 -	42.7 -
6/ 5/	- -	- -	- -	- -	- -	- -	- -	N.A. -	3,809 -	- -	- -	- -
211 330	1 -	- -	17 -	18 -	- -	Mt. Pleasant, Mich.	- -	5 5	1,988 -	9.0 -	6.5 -	106.1 -
79,815 123,000	78 -	9,215 -	198 -	9,491 -	- -	West half of W. Va., Franklin & Pittsburgh, Pa., Cleveland, Ohio, Robinson, Ill.	56 -	336 500	744,958 -	12.7 -	12.3 -	106.2 -
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
6/ 5/	- -	- -	- -	- -	- -	- -	- -	N.A. -	3,789 -	- -	- -	- -
73,545 113,300	27 -	14,738 -	8,749 -	23,514 -	2,901 -	Jefferson, St. Charles, St. Mary, Iberville, St. Landry & Tensas Counties, La.	339 -	1,522 2,300	232,225 -	113.7 -	107.2 -	316.7 -
8,942 13,400	- -	293 -	357 -	650 -	- -	Glacier County, Mont., Park, Washakie, Fremont, Weston, Nichrara, Johnson, Carbon, Kimball, Cheyenne Counties, Wyo.; Logan, Morgan, Washington Counties, Colo.	- -	482 700	77,490 -	8.4 -	2.2 -	115.4 -
-	-	-	-	-	-	-	-	-	-	-	-	-
165,223 253,000	227 -	321 -	2,783 -	3,331 -	6 -	SW Kansas; Eastern Okla.; Panhandle, & NC Texas.	22 -	2,648 4,000	1,903,076 -	1.8 -	0.4 -	86.8 -
21,173 31,700	- -	12 -	877 -	889 -	- -	NE Texas; NW & NC La.; & SW Ark.	- -	617 940	334,371 -	2.7 -	0.8 -	63.3 -
99,218 4,000	922 -	757 -	19,166 -	20,845 -	21 -	SW La.; E, SE, S, NC, WC & W. Texas.	404 -	15,745 24,000	2,650,553 -	7.9 -	1.9 -	188.3 -
80,919 1,000	482 -	1 -	2,369 -	2,852 -	- -	Eddy, Lea Counties, SE New Mexico.	15 -	1,932 2,940	684,797 -	4.2 -	1.3 -	118.2 -
N.A. 6,300	- -	- -	- -	- -	- -	Moffat, Rio Blanco Counties, Colo.; Daggett County, Utah, Sweetwater County, Wyo., San Juan, McKinley Counties, New Mex.	- -	N.A. 100	170,826 -	N.A. -	N.A. -	N.A. -
- 3,700	- -	- -	- -	- -	- -	Uinta County, Wyo.	- -	- 50	- -	- -	- -	- -
- 1,900	- -	- -	- -	- -	- -	-	- -	- 25	- -	- -	- -	- -
,580 ,370	76 -	- -	1,060 -	1,136 -	63 -	Fresno, Kings, San Luis Obispo and Kern Counties, Calif.	- -	1,078 1,645	297,450 -	4.0 -	0.4 -	207.0 -
,421 ,600	788 -	4 -	461 -	1,253 -	4 -	Santa Barbara, Ventura, Los Angeles, Orange Counties, Calif.	44 -	1,105 1,675	274,212 -	4.6 -	0.6 -	191.2 -
,468	2,616	25,341	36,310	64,267	2,995		880	25,548	7,459,918	9.0	5.6	140.3
,000	-	-	-	-	-		-	39,000	11,415,000	-	-	-

980.

Estimates of water use for the year 1980 were made on the assumption that 11.415 trillion cubic feet of natural gas will be processed and, in processing this gas, the total water use would be increased about 53 percent over 1954. Gains exceeding the national average are expected in the upper Missouri River, Colorado Basin, Great Basin, and Pacific Northwest regions.

No estimates are tabulated for the year 2000 since it is believed the water use in natural gas liquid plants may approximate those of 1980.

Water requirements for the oil shale industry will probably become significant after 1965. By 1975 the annual water requirements are expected to reach 82 billion gallons in the production of 456 million barrels of shale oil, or 4.25 gallons of water per gallon of oil. The water use for 1980 and 2000 should approximate 82 billion gallons since shale oil production is expected to level off after 1975.

Most of the oil shale deposits occur in western Colorado, southwestern Wyoming, and eastern Utah, the greater part of which lie within the Colorado River region.

The 1954 average national water use per unit for each phase of the petroleum and natural gas industry, calculated from census returns, is shown in table 8. The data influenced the water use forecasts for the industry but were adjusted to suit local probabilities.

TABLE 8.—*Water intake, discharge, and gross water use in 1954 per unit of production or processing in the petroleum and natural gas industry*

[In gallons of water]

Category	Per unit	Intake	Discharged	Gross use	Net use
Crude petroleum	Barrel	35.4	57.8	(1)	(2)
Drilling wells	Foot drilled	40.3	14.3	(1)	26.0
Crude oil processing	Barrel	480.3	437.5	1,607.8	42.9
Natural gas liquids	Thousand cubic feet gas processed.	9.0	5.6	140.3	3.4

(1) Not available.
(2) No net, discharge exceeds intake.

Estimates of water use by the petroleum industry for 1980 were based upon an estimated total crude petroleum production of 3,474 million barrels, assuming the future price of crude will justify exploration and development. Allowance was made also for increased water intake and discharge per barrel of crude produced in the different regions. These increases average 15 percent in water intake and 25-percent increase in water discharged per barrel of production. It is believed the upper Missouri River, Colorado River, and Pacific Northwest regions will register substantial gains in water use, but the western gulf, upper Arkansas-Red River, and Ohio River regions will continue as the largest users of water.

No water estimates for petroleum production for 2000 are tabulated. The water use by region may approximate those for 1980. By 2000 the peak of domestic production of crude oil and natural gas probably will have been passed but the volume of water intake and discharged probably will equal the 1980 figure even though there may be a slight decrease in crude production.

Other factors considered in estimating regional water use by the crude petroleum and natural gas industries of the future included production trends in each region, trend in water flooding, and secondary recovery techniques now being developed. Improved technology may decrease markedly the volume of water intake in the future.

ANTHRACITE

Anthracite is produced in only 2 of the 22 water-use regions, the Delaware and Hudson region and the Chesapeake Bay region. Drainage from the anthracite producing area of the Delaware and Hudson region enters only the Delaware River Basin. Anthracite mine drainage from the Chesapeake Bay region enters the Susquehanna River.

A special tabulation of the Bureau of the Census water-use data for 1954 was used as a basis for estimating water use by the anthracite industry in the years 1980 and 2000.

The methodology in estimating for 1980 and 2000 was as follows. The rate of decline in the percentage contribution by anthracite to total energy supplies during 1956–58 was determined and this rate of decline was projected to 1980 so as to determine the estimated percentage contribution by anthracite to total energy requirements. It was assumed arbitrarily that the percentage contribution by anthracite to total energy supplies would not change between 1980 and 2000: Total energy requirements for 1980 were projected from the estimate for 1975 made by Resources of the Future, Inc. The projection for 1980 was made at the same annual rate as used by Resources of the Future, Inc., for the 1955–75 period (3.275

percent per year). It was arbitrarily assumed that the annual rate of growth of energy requirements would be reduced to 2.75 percent during the 1980–2000 period. The total energy requirements for 2000 were determined by projection of this lower rate of increase of 1980. The aforementioned percentage contributions by anthracite to total energy were used to determine the estimated production of anthracite in 1980 and 2000.

The gallons of water used per ton for 1954 were determined for each of the five categories of water use and applied to the estimated production of anthracite so as to obtain total water requirements of the respective items for 1980 and 2000. These totals of water use were broken down to river basins by applying the percentage distribution shown in the five items for the respective river basins in 1954. Results are tabulated in table 9.

Specific data on sources by river basins and quality of water used by the anthracite industry in 1954 are not available from the census data because of confidentiality restrictions. However, it may be generalized that nearly all water used is obtained either from surface water systems or by pumping from mines. Only a minor percentage would be derived from ground water systems. Of the total water intake for the anthracite industry in 1954, 47 percent was pumped from mines. All of the mine water would be acid and an undeterminable but probably sizable proportion of the water from surface systems also would be acid. All water used in the anthracite regions would be classed as fresh water.

The Pennsylvania anthracite producing region is located in northeastern Pennsylvania in the following counties: Carbon, Columbia, Dauphin, Lackawanna, Lancaster, Lebanon, Luzerne, Northampton, Northumberland, Schuylkill, Snyder, Sullivan, Susquehanna, and Wayne. By State law, all water discharged from anthracite preparation plants must be held in settling ponds until all sediments have been removed and only clear water enters the streams. Virtually all of the water discharged to the streams would be acid but the acidity is neutralized so that all major rivers flowing through the producing region have alkaline water shortly after the river course is outside the producing region. Consequently, the effluent from anthracite operations has no effect upon the metropolitan areas named in the attachments to the Senator's letter.

There are no foreseeable significant changes in the present pattern of water use by the anthracite industry. Similarly, no special problems of water supply, demand, pollution, or treatment can be foreseen in relation to operations of the anthracite industry.

TABLE 9.—*Water use by Pennsylvania anthracite industry, 1954, and estimates for 1980 and 2000*

[In millions of gallons]

	Water region 11, Delaware and Hudson Rivers			Water region 12, Chesapeake Bay			Total		
	1954 [1]	1980 [2]	2000 [2]	1954 [1]	1980 [2]	2000 [2]	1954 [1]	1980 [2]	2000 [2]
Water intake, excluding mine water	4,776	2,800	5,000	9,751	5,700	10,000	14,527	8,500	15,000
Water discharged, excluding mine water	3,599	2,100	3,700	7,473	4,400	7,700	11,072	6,500	11,400
Mine water intake	3,718	2,200	3,800	8,969	5,200	9,300	12,687	7,400	13,100
Mine water discharged	27,410	16,000	28,300	57,555	33,700	59,300	84,965	49,700	87,600
Gross water used, including recirculated	18,287	11,900	21,000	70,714	46,000	81,100	89,001	57,900	102,100

[1] Department of Commerce, Bureau of Census, special tabulation.

[2] Estimated.

BITUMINOUS COAL AND LIGNITE

Water-use estimates for the bituminous coal and lignite industries in 1980 are based on census data on water for 1954 in relation to Bureau of Mines data on coal production in 1954 and future coal requirements to meet expanding energy demands, including the steam generation of electric power. Estimates of coal production by 1980 range between a 55-percent and a 155-percent increase over 1954. Considering changes in methods and efficiencies of mining and processing, changes in fuel consumption patterns, and the extent to which nuclear energy may minimize the need for coal, a figure of 90-percent increase was used as being indicative of the general magnitude of anticipated coal production and related water requirements in 1980. Water demand estimates are presented in tables 10 and 11.

Whether there will be a continuing increase in coal demand after 1980 is conjectural at the present time, because of uncertainties pertaining to nuclear power and to the availability and use of oil and natural gas. With a continuing increase in the rate of population growth and in economic development, water requirements for coal will continue to increase until 1980. Water requirements for coal in 2000 probably will not exceed those of 1980, due to technologic changes and other factors. They could be less, however, as a result of advanced technology in the recirculation and reuse of water, particularly in cleaning and processing activities. Such advances could be an influence also in reducing water requirements by 1980.

The forecast of no increase in water use for coal for 2000 should not be taken to mean necessarily that there will be no increase in the use of coal. The price of water is increasing in coal mining areas. The availability of water is decreasing. Hence, the demand for water per ton of coal in 2000 will likely be less than in 1980.

While there may be geographical changes and shifts in coal production in the next 20 to 40 years, as yet there is not enough reliable, authoritative information upon which adequately to appraise the extent to which complex competitive forces and variations in types of energy demand may bring about material changes. The tendency to build electric generation plants close to coal mines in both the West and the East can have significant local impact on water use. Significant local changes have occurred in the past.

The average gallons per ton for each of the census items in 1954 have been presented in tables 12 and 13. The wide fluctuation in gallons per ton in the various water use regions make it inadvisable to use published information to estimate for the regions where data are not available because of confidentiality rules of census.

TABLE 10.—*Water use at bituminous coal and lignite mines in 1954* [1] *and estimates for 1980*

[In millions of gallons]

Water-use region	Production of bituminous coal and lignite in 1954 (net tons)	Water intake, except mine water		Water discharged, except mine water		Mine water intake (used)		Mine water discharged		Gross water use, including recirculation	
		1954	1980	1954	1980	1954	1980	1954	1980	1954	1980
New England	----	----	----	----	----	----	----	----	----	----	----
Delaware and Hudson Rivers	----	----	----	----	----	----	----	----	----	----	----
Chesapeake Bay	7,141,372	31	59	28	53	3	6	2,723	5,174	584	1,110
Southeast region	10,279,158	1,495	2,841	1,021	1,940	350	665	10,289	19,549	9,908	18,825
Eastern Great Lakes region	73,356	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Western Great Lakes region	135,181	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Ohio River region	285,182,798	16,590	31,521	10,269	19,511	3,857	7,328	122,074	230,041	84,424	160,406
Cumberland River region	12,396,849	450	855	420	798	(2)	(2)	5,499	10,448	(2)	(2)
Tennessee River region	12,838,423	79	150	62	118	193	367	515	979	362	688
Upper Mississippi River region	39,418,985	2,366	4,495	1,348	2,561	1,961	3,726	1,967	3,737	14,189	26,959
Lower Mississippi River region	----	----	----	----	----	----	----	----	----	----	----
Upper Missouri River region	6,095,679	72	137	3	6	----	----	751	1,427	72	137
Lower Missouri River region	2,870,241	282	536	231	439	242	460	244	464	955	1,815
Upper Arkansas-Red Rivers region	1,942,750	62	118	7	13	128	243	124	236	317	602
Lower Arkansas-Red-White Rivers region	2,782,880	189	359	166	315	(2)	471	467	887	1,517	2,882
Western gulf region	1,304,456	----	----	----	----	(2)	(2)	(2)	(2)	(2)	(2)
Upper Rio Grande and Pecos River region	19,498	----	----	----	----	(2)	(2)	(2)	(2)	(2)	(2)
Colorado River region	7,298,603	309	587	185	352	63	120	1,257	2,388	2,442	4,640
Great Basin region	637,156	----	----	----	----	----	----	13	25	----	----
Pacific Northwest region	619,209	(2)	(2)	(2)	(2)	49	93	(2)	(2)	316	600
Central Pacific region	3,088	(2)	(2)	----	----	----	----	----	----	(2)	(2)
South Pacific region	----	----	----	----	----	----	----	----	----	----	----
Total [3]	391,039,682	[4]22,201	[4]42,182	[4]13,985	[4]26,572	[4]7,207	[4]13,692	[4]147,355	[4]279,975	[4]116,271	[4]220,915

[1] Bureau of Census water data.

[2] Data not available due to disclosures.

[3] Excludes Alaska.

[4] Figures do not add to total due to concealments.

TABLE 11.—*Water intake at bituminous coal and lignite mines by source in 1954* [1] *and estimates for 1980*

[In millions of gallons]

Water-use region	Production of bituminous coal and lignite in 1954 (net tons)	Public water systems		Company surface water systems		Company ground water systems		Combinations of systems and source not specified	
		1954	1980	1954	1980	1954	1980	1954	1980
New England									
Delaware and Hudson Rivers									
Chesapeake Bay	7,141,372	21	40	(2)	(2)	(2)	(2)	(2)	(2)
Southeast region	10,279,158	(2)	(2)	1,388	2,637	93	177	(2)	(2)
Eastern Great Lakes region	73,356	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Western Great Lakes region	135,181	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Ohio River region	285,182,798	726	1,379	(2)	(2)	(2)	(2)	1,753	3,331
Cumberland River region	12,396,849			(2)	(2)	(2)	(2)	24	46
Tennessee River region	12,838,423	12	23	(2)	(2)	16	30	(2)	(2)
Upper Mississippi River region	39,418,985	132	251	1,279	2,430	562	1,068	398	747
Lower Mississippi River region									
Upper Missouri River region	6,095,679	(2)	(2)			63	120	(2)	(2)
Lower Missouri River region	2,870,241			110	209	62	118	110	209
Upper Arkansas-Red Rivers region	1,942,750	(2)	(2)	32	61	2	4	(2)	(2)
Lower Arkansas-Red-White Rivers region	2,782,880	(2)	(2)	171	325	2	4	(2)	(2)
Western Gulf region	1,304,456								
Upper Rio Grande and Pecos River region	19,498								
Colorado River region	7,298,603	20	38	167	317	119	226	3	6
Great Basin region	637,156								
Pacific Northwest region	619,209	(2)	(2)	(2)	(2)	(2)	(2)	92	175
Central Pacific region	3,088	(2)	(2)	(2)	(2)				
South Pacific region									
Total [3]	391,039,682	[4] 956	[4] 1,816	[4] 15,240	[4] 28,958	[4] 3,574	[4] 6,791	[4] 2,421	[4] 4,619

---

[1] Bureau of Census water data.

[2] Data not available due to disclosures, per Census tabulation.

[3] Excludes Alaska.

[4] Figures do not add to total due to concealments.

TABLE 12.—*Water intake at bituminous coal and lignite mines in 1954, in gallons per ton* [1]

Water use region	Production of bituminous coal and lignite, 1954 (net tons) [2]	Public water systems	Company surface water systems	Company ground water systems	Combinations of systems and source not specified
New England					
Delaware and Hudson River					
Chesapeake Bay	7,141,372	2.9	(3)	(3)	(3)
Southeast region	10,279,158	(3)	135.0	9.0	(3)
Eastern Great Lakes region	73,356	(3)	(3)	(3)	(3)
Western Great Lakes region	135,181	(3)	(3)	(3)	(3)
Ohio River region	285,182,798	2.5	(3)	(3)	6.1
Cumberland River region	12,396,849		(3)	(3)	1.9
Tennessee River region	12,538,423	.9	(3)	1.2	(3)
Upper Mississippi River region	39,418,985	3.3	32.4	14.3	10.0
Lower Mississippi River region					
Upper Missouri River region	6,095,679	(3)		10.3	(3)
Lower Missouri River region	2,870,241		38.3	21.6	38.3
Upper Arkansas-Red Rivers region	1,942,750	(3)	16.5	1.0	(3)
Lower Arkansas-Red-White Rivers region	2,782,880	(3)	61.4	.7	(3)
Western Gulf region	1,304,456				
Upper Rio Grande and Pecos River region	19,498				
Colorado River region	7,298,603	2.7	22.9	16.3	.4
Great Basin region	637,156				
Pacific Northwest region	619,209	(3)	(3)	(3)	148.6
Central Pacific region	3,088	(3)	(3)		
South Pacific region					
Total [4]	391,039,682	2.4	39.0	9.1	6.2

---

[1] Based on Bureau of Census Water Data and Bureau of Mines production data.

[2] Source: U.S. Bureau of Mines.

[3] Data not available due to disclosures—per Census tabulation.

[4] Excludes Alaska.

TABLE 13.—*Water use at bituminous coal and lignite mines in 1954, in gallons per ton* [1]

Water use region	Production of bituminous coal and lignite, 1954 (net tons) [2]	Water intake, except mine water	Water discharged, except mine water	Mine water intake (used)	Mine water discharged	Gross water use, including recirculation
New England	....	....	....	....	....	....
Delaware and Hudson River	....	....	....	....	....	....
Chesapeake Bay	7,141,372	4.3	3.9	0.4	381.3	81.8
Southeast region	10,279,158	145.4	99.3	34.0	1,001.0	963.9
Eastern Great Lakes region	73,356	(3)	(3)	(3)	(3)	(3)
Western Great Lakes region	135,181	(3)	(3)	(3)	(3)	(3)
Ohio River region	285,182,798	58.2	36.0	13.5	424.5	296.0
Cumberland River region	12,396,849	36.3	33.9	(3)	443.6	(3)
Tennessee River region	12,838,423	6.2	4.8	15.0	40.1	28.2
Upper Mississippi River region	39,418,985	60.0	34.2	49.7	49.9	300.0
Lower Mississippi River region	....	....	....	....	....	....
Upper Missouri River region	6,095,679	11.8	.5	....	123.2	11.8
Lower Missouri River region	2,870,241	98.2	80.5	84.3	85.0	332.7
Upper Arkansas-Red Rivers region	1,942,750	31.9	3.6	65.9	63.8	163.2
Lower Arkansas-Red-White Rivers region	2,782,880	67.9	59.7	89.1	167.8	545.1
Western Gulf region	1,304,456	....	....	(3)	(3)	(3)
Upper Rio Grande and Pecos River region	19,498	....	....	(3)	(3)	(3)
Colorado River region	7,298,603	42.3	25.3	8.6	172.2	334.6
Great Basin region	637,156	....	....	....	20.4	....
Pacific Northwest region	619,209	(3)	(3)	79.1	(3)	510.3
Central Pacific region	3,088	(3)	....	....	....	(3)
South Pacific region	....	....	....	....	....	....
Total [4]	391,039,682	56.8	35.8	18.4	376.8	297.3

[1] Based on Bureau of Census water data and Bureau of Mines production data.

[2] Source: U.S. Bureau of Mines.

[3] Data not available due to disclosures, per census tabulation.

[4] Excludes Alaska.

The national average in gallons per ton of coal would seem to be the only guide to forecasting demand in the basins where data are absent in the 1954 census. The variation in reported use is too great to make such a figure valid.

Bureau of Mines engineers report that a trend exists in the coal industry to use less water than in previous years. Coal washing plants are becoming more efficient now and are effectively conserving water supplies. Recirculation of water in some plants is resulting in appreciable reduction in demand. No canvass of the coal industry water use was made for 1958, however, as was made for the metals and nonmetallic mineral industries.

CONCLUSIONS

The estimates of water use for the various segments of the mining industry have been made by Bureau personnel most qualified to make such estimates, using the best available figures. Obviously the estimates can be no better than the figures upon which they were based.

The recent experience of the Bureau of Mines in collecting water-use data has pointed out the many problems connected with acquiring information in this field. For example, many respondents have inaccurate knowledge of the water they use; many different units are used in measuring water leading to some confusion as to the meaning of the figures; use of water varies so widely from place to place that it is difficult to evaluate questionnaires; and where several products are produced in an integrated operation it is impractical to allocate the water use among the various products.

Water-use figures compiled for the metals and nonmetals industries are believed to be conservative because reports showing inconceivably large figures were thrown out as were also reports from cement plants which were considered to be in the manufacturing rather than the mining category, although, undoubtedly some water was used in producing the raw material.

Estimates of water use in the projection years may not be as conservative as the water-use figures for 1958, as conservation of water use may be practiced more widely in the future than at present. An example of this may be found in the steel industry which utilizes water at a rate varying between 50,000 and 65,000 gallons per ton in most of the industry but in one western plant a water use of only 1,500 gallons per ton of steel is reported. The amount of water used at any mineral plant is affected principally by water cost and its availability. Because of the shortage and high price of water, the western steel plant mentioned could not operate unless it conserved its water supply.